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Publicity.

John D. Archbold, vice-president of the Standard Oil Co., makes the following unexpected acknowledgment in the "Saturday Evening Post" of Dec. 7: "I say with the utmost frankness that I believe the policy of silence which the company maintained for so many years, amid the misrepresentations which assailed it, is a mistaken policy, which, if earlier abandoned, would have saved the company from the injurious effects of much of that misrepresentation." The publicity policy of the great corporation has been for so long one of absolute silence concern-

ing everything except its products, that this announcement by Mr. Archbold is very significant of the present influence of journalism. Some great railway companies long ago recognized that secrecy concerning everything in which the public was concerned had a bad effect on their place in public opinion. Some of the most gifted men in the journalistic field have undertaken this kind of publicity work, one of them even joining the staff of the Standard Oil Co. some months ago. It is safe to say, however, that this step, so far as the Standard Oil Co. is concerned, was taken too late; the public has been led to believe altogether too much evil of this great corporation to look upon its tardy recognition of publicity as anything but a desire to fight back as well as it can against its avowed enemies, who have long shown themselves to be masters of the resources of paper and pen.

It was natural enough for the great commanders of commerce and manufacturing, who were engaged in building up enormous business enterprises, to feel that the public had no right to information concerning their undertakings so long as they kept within the law, and that information concerning the products was all that there was any reason for giving out. Unquestionably this feeling has gradually changed, and it is now seen to be good policy to allow for two characteristics of the average man. The first is his legitimate inquisitiveness concerning the manner in which a product that he uses is made, and the second is a determination to buy that product just as low as anybody else. When a man delves into the secrets of nature in an intelligent manner he is considered a scientist, although very likely his researches may be of no immediate value. On the other hand, when he endeavors with equal intelligence to ascertain how a product is manufactured, so that he may judge for himself what improvements can be made in it without increasing its cost above what he wishes, he is, or was, regarded as altogether too inquisitive. Now these two manifestations of curiosity are really the same, and it is the recognition of this fact that has led to the increasing appreciation of what legitimate publicity means. The fact that the Standard Oil Co. has at last abandoned in a measure its policy of stony silence for that of reasonable publicity is one of those indications of the great business shrewdness that is expected in the management of that corporation.

Another aspect of this matter was referred to in this journal last week in the extracts from the address by Dr. James Douglas at the Toronto meeting of the American Institute of Mining Engineers. Dr. Douglas discussed the extent to which secrecy in the arts was desirable. His arguments for and against such secrecy were well stated, and the address as a whole is one of those contributions to engineering literature that deserve study by every engineer. A little reflection will show, however, that the views of secrecy outlined in the address of Dr. Douglas do not differ from those of publicity outlined by Mr. Archbold. Both agree that secrecy does not pay in these days in most enterprises. The reason for this is obvious. There are some special processes which can occasionally be maintained as trade secrets, and occasionally some one is able to devise a machine which it is advisable to operate in a secret manner. As a rule, however, secrecy is a cloak for ignorance. There are too many thoroughly competent men ready to undertake almost every kind of work to make the average secret, either of process or of organization, of much use. There are three things that count in large affairs. One of them, the most important, is an organization of competent men thoroughly inspired by esprit de corps. The second thing is sound financial management,

and the third thing is control of the resources from which raw materials are obtained. At the present date patents are largely things to fight over, secret processes are things to worry over, and an inefficient staff of men is a thing to weep over. Given a good staff, a good supply of raw materials and a financial management that is neither reckless nor timid, and the success of any business is pretty well assured. It is safe to say that one of the first things a corporation of this nature will take in hand is its arrangements for securing legitimate publicity. The art of doing this is still in its infancy. There seems to be a feeling that by spending a little money in the advertising pages of various publications it is possible to control the reading pages, although this is not the case with any reliable journal. The way to secure publicity is that outlined by Dr. Douglas, to give out information which is likely to interest the people who subscribe to the various papers or join the important engineering societies. Just as soon as a corporation understands that there are two kinds of publicity, one entirely appropriate to advertising pages and trade catalogues, and the other appropriate to reading pages, and that the two are as far apart as the North and South poles, it has attained knowledge that, rightly applied, will enable it to gain satisfactory publicity in a manner and to an extent possible in no other way.

Tests of Full-Size Reinforced Concrete Compression Members.

Compressive tests of concrete cubes from twelve inches downward are much like those of steel eye-bars, so many in number as to leave little to be desired. The same is true concerning the tensile tests of cement and mortar briquettes, and it is even more true concerning the tensile tests of steel. In spite of this abundance of experimental investigations of the two materials of the concrete-steel combination there is a dearth of empirical data relating to the reinforced concrete compression member, although the engineering laboratory of the University of Illinois and the testing bureau at the Watertown Arsenal have made experiments valuable in their way, but not yet conclusive concerning some important features of reinforced concrete column design. The tests of banded columns have disclosed information of much importance and have aided greatly in giving the banded concrete column sufficient standing to secure its adoption in many buildings, but a little reflection makes it apparent that some of the most valuable information which can be established by experimental investigation cannot be obtained from columns of that type.

The longitudinal steel in banded columns is of very small sectional area and usually in such shape as to offer no sensible resistance to direct compression in itself, even when such angles are employed as have occasionally been used in this particular class of column tests. The natural and inevitable consequence is, first, a certain heterogeneous action of the two materials, in consequence of which the steel bars or rods tend to buckle under even a small compressive loading and hence to split the concrete surrounding them. This tendency is, of course, opposed and controlled by the steel banding, provided it is heavy enough. Some experiments seem to show that the banding does not in general come into positive effective action until the concrete has been loaded beyond any intensity of working stress which has yet been prescribed for the concrete; in other words, the lateral expansion of the concrete under the maximum working loads of engineering structures is not enough to

develop any material amount of support from the banding steel. Or, to put it in another way, the ordinary round rod steel banding does not act quickly enough to meet the requirements of usual loading on the concrete, although it gives material support to the latter under loads imposed by the testing machine far beyond the maximum working stress in any structure. While, therefore, the tests of full-size banded columns produce results which fully illuminate the conditions attending the action of a wire-wound concrete core, they have not thrown much light upon the ultimate resistance of a combination column in which the steel is so distributed as to form a full load-carrying steel column, while at the same time it envelops and supports as an effective banding the concrete within it.

This latter type of column, used successfully in the building in which this journal is published, is a true concrete-steel column in the full sense of the expression. The combined action of the two materials is radically different from that of any series of concrete-steel columns yet tested. The load acts directly upon both steel and concrete from the initial loading to the full working stress. The steel performs its function promptly and without waiting for the development of lateral strains in the concrete. While the lacing bars may, and undoubtedly will, yield to some extent to the flexure induced by the lateral enlargement of the concrete, it must be remembered that when properly designed the flexure of the lacing bars will afford considerable lateral support to the concrete and, within the working stresses permitted in that material, it may be even quite as much as or more than that offered by wire banding. If it be further remembered that a large part of the mass of the concrete at the four corners of a column is embraced throughout its entire length by the steel angles, and thus held far more effectively in this respect than by any possible wire banding, it is clear that the enclosed concrete must be substantially supported. At the same time the crucial test, of course, lies in the actual loading to failure of full-size members.

There are other features of these combinations of different materials, the influence of which can only be satisfactorily determined by experimental investigation. It is ordinarily assumed that in all types of columns the intensities of stress are directly proportional to the compressive strains produced, and as a general law that is certainly true, but the effect upon the stresses in the concrete due to the partial prevention of the lateral strains by enclosure has not yet been demonstrated. It is quite supposable that in the combination of a steel column enclosing concrete the effective support of the latter by the steel surrounding it may throw upon the concrete sensibly more stress than would be the case with unrestricted lateral movement. Under such conditions the steel would carry with increasing loads a less proportion of the total and the concrete more. A careful set of measurements of the shortening of a test column under loads gradually advancing to that producing failure would yield sufficient information to settle this and other similar questions regarding the interaction of the two elements. There can be little or no question about the wisdom and safety of the present allowed stresses by the Bureau of Buildings of New York in columns of this type, especially as there are numerous tests of 1:2:4 concrete, showing that even in ordinary cubes a working stress for the purpose indicated of 750 lbs. per square inch may carry with it at the age of six months a safety factor between 5 and 6. It is much to be desired that in the mass of material testing now being planned ample provision may be made for full experimental investigation of this type of column which has so much to commend it from every point of view.

Vocational Schools.

The discussion which has been carried on in the columns of this journal recently is one that stimulates thought on educational topics. No country has a more active interest in education than our own and nowhere have experiments in education been tried on a more lavish scale. Some of them have been highly successful, others have not. In the early days of the country the situation was a very simple one. There were at the bottom the common schools, covering a range roughly equivalent to the first ten years of the present graded schools. Beyond these were a limited number of schools preparatory to the existing colleges and doing something less than the present classical high school. If these were not accessible the student was likely to prepare for college in his pastor's study. Then came the college, with a rigid course devoid of ornamentation but crudely effective. For professional study there was the divinity school, law and medicine being commonly studied in the office of the practitioner. It is only within the present generation that technological training has become reasonably accessible to those who are not desirous of the old classical training, now very much out of vogue.

The present technological school is the outcome of a demand for practical studies which could be applied to the occupations of every day life. It was roundly abused in its beginning, more for social than for strictly educational reasons. It was looked upon as the resort of young men of small means and mediocre attainments who desired with a strictly commercial instinct to turn studies into dollars in the minimum possible time. At present that stigma has worn off, for the point of view has changed and the growth of industry has opened careers which demand for preparation something more than the old education had to give. And by reason of the same sort of demand, there have sprung up a host of what one may call rudimentary technical schools, and institutions even more strictly vocational, such as correspondence schools and trade schools, teaching for better or worse practical things which can be turned into the coin of the republic. Besides these there are the so-called business colleges, which exist simply on account of the incapacity of the public school to come down out of the moonshine long enough to teach common things thoroughly.

Now the vocational school, by whatever name you choose to call it, exists in honorable recognition of the fact that the grand army of the world's workers must have privates and non-commissioned officers as well as staff and line. One may try to conceal their function behind fine spun theories regarding the superlative cultural value of handicraft, but the fabric is transparent. The students of the vocational school, whether it be a manual training, a trade, or a business school, are there because they lack the time, taste or capacity for pursuing the so-called "higher" education. Many of them are the better for their choice, and all are going honorably forward to find their places in the ranks. Some will win their commissions in due season, others will stay privates and corporals. It is sheer snobbery to look down upon the vocational schools, but it is equally culpable stupidity to suppose that they exist for psychological rather than utilitarian reasons. There are doubtless some boys whose intellects can be stimulated only through their hands, but these cases are essentially unfortunates like those deficient in sight or hearing to whom the ordinary channels of communication are unhappily closed.

The "manual training" high school occupies a somewhat anomalous position at the head of the list. At present it turns out neither engineers

nor finished craftsmen, but gives a good sound training so far as it goes. There is a pretty general feeling among engineers and manufacturers who have considered the subject that if the manual training school could go about two years further it would prove invaluable in the training of young men fit to be foremen and superintendents, the sergeants and lieutenants, so to speak, of industry, not out of line for promotion. A very few schools which actually give just about this training can show a remarkably successful list of graduates. It would be an admirable thing if the manual training schools could generally be expanded into this particular sphere of usefulness.

The trade schools have not been so successful as one could wish, mainly on account of unreasoning prejudice on the part of organized labor. The Y. M. C. A. industrial courses and the correspondence schools, by dodging around this obstacle, have, on the other hand, made substantial progress. The trade schools certainly have the possibility of very great usefulness, since the lack of trained workmen is being very severely felt in American industry. They ought to be actively encouraged and made an efficient part of the educational organization. If they were vigorously pushed the prejudice which now handicaps them would soon disappear and one would not be under the necessity of hunting for foreign-trained workmen in many branches of industry. At present all that is done in the way of training for trades is a mere drop in the bucket. Not every man can be made into a good workman, but every man ought to have the chance. With all the millions that are being spent for the cause of education in the United States it is a shame that more and better trade schools are not in operation. They are far more necessary to the national future than are the scores of petty colleges that provide sham B.A. and B.S. degrees in scores of self-satisfied communities. The country could well exchange a job lot of shabby "universities" for as many thoroughly good vocational schools. Education as at present organized is unhappily more extensive than intensive. This is not altogether the fault of the educators, but rather of the community that too frequently wants its culture like its parlor—plenty of veneer and varnish, and never mind about the joints. It is perhaps only a transitory foible of a rapidly growing country, but it is serious in that it leaves to the future the task of patching things up as best it can. It is time to drop makeshifts and to begin accumulating for the next generation a heritage of honest work in culture as in industry. It is a national boast to give every man a fair chance. Is it not time to make that boast good by giving every man an opportunity to learn how to win an honest livelihood?

Common Sense about Smoke Abatement.

The Chamber of Commerce of Syracuse, N. Y., is to be congratulated on having published the best report on smoke abatement that has yet appeared. It combines scientific accuracy with an appreciation of what is practicable, and is neither disfigured by questionable theory nor marred by the wordiness which disfigures so much that has been written on this important subject. Moreover, from cover to cover the report is characterized by a sanity of view that is gratifying. While it has been prepared for the use of Syracuse citizens, the work has been so thoroughly well done that its advice is applicable in most of our cities. If it is studied carefully and its conservative recommendations are followed, the manufacturers whose plants are now emitting dense smoke and the people who are subjected to inconvenience by such smoke will alike be bene-

fited. It is not surprising that the report is such a good one for the Chamber of Commerce appointed a committee to carry on the investigation which was fully able to execute its task in a proper manner. Four of the members were men everywhere recognized as authorities in industrial engineering affairs, while the others were equally competent to give advice on other features of the smoke problem. Plenty of time was taken by the committee to become acquainted with the conditions in various cities and to study the operation of devices for preventing smoke. Correspondence was conducted with cities having smoke-prevention ordinances and every attempt was made to find out what had been accomplished in this country and abroad. The report is consequently one of those documents which will become a standard authority, and it is to be hoped that the Syracuse Chamber of Commerce has printed an edition sufficiently large to enable engineers and municipal officers in other cities to obtain copies.

It is gratifying to notice that the committee has resolutely refused to lend itself to the position taken by some sanitarians that all smoke is injurious to public health. Very likely it is when present in large quantities, but there is a great difference between the atmosphere of the mill district of Pittsburgh and the atmosphere of Syracuse. In Syracuse the problem of smoke abatement is essentially one of aesthetic and economical conditions rather than one of hygiene. This is generally the case elsewhere and the sooner the fact is recognized the sooner will we have good progress in smoke prevention. If an ordinance is passed by a city which makes absolute prevention of smoke necessary at all times, the way is open for endless graft. Such a condition is not practicable nor is it necessary. There are a number of appliances on the market which will prevent smoke entirely under most conditions, when properly applied and managed, and the worst condition they will permit is a gray haze at the time fresh coal is charged on the fires. When the smoke given off by all plants is reduced to this extent, about all that is really necessary has been accomplished.

A great trouble with attempts made in the past to abate smoke has been due to the endeavor to place the matter in the hands of the police, or to take some equally drastic action. This is unfortunate. The history of smoke abatement demonstrates beyond any question that success can only be attained when the manufacturers whose plants belch forth black clouds and the owners of small boiler plants which are offenders in the same way, are brought to an appreciation of the importance to themselves of stopping such practices. Men told peremptorily to stop the nuisance their premises are causing, under penalty of heavy fine, are not approached in a tactful manner. Up to date no attempt to introduce such a policy in an American city has been successful, and most such attempts have been flat failures. On the other hand, marked success has been the result of harmonious action on the part of manufacturers and others to remedy this trouble. This has been shown particularly in the case of Cleveland, where great improvements are being made and arrests and fines are rarely necessary. Of course there will be cases in all cities where the law must be invoked to stop the nuisance. This is to be expected, but it is highly desirable that the number of such cases be restricted entirely to those parties who by nature are reluctant to do anything which is desirable for the public welfare.

It is really surprising that so little has been accomplished in the way of a general education of the people concerning the causes of smoke. The essential facts are readily understood. They do not require a technical education nor a deep knowledge of the secrets of science. The report

issued by the Chamber of Commerce of Syracuse states both the principles of combustion and the causes of smoke in six pages of ordinary octavo size. A study of these pages is a matter of half an hour or so, and once the information they give is learned thoroughly the reader is in a position to talk intelligently on the subject of smoke abatement. He is also in a position to avoid accepting the preposterous claims occasionally made for patented devices to bring about smokeless combustion. Probably one reason that so many people are reluctant to try to prevent smoke is the fear that they will fall into the hands of some salesman whose apparatus is made to sell and not to work. Such people will find in this report a fair statement of what can and cannot be accomplished by different types of apparatus. The committee states emphatically that there is no one apparatus which will accomplish everything to be desired in every place, and it gives a warning that the selection of the apparatus for smoke prevention is something which should be entrusted if practicable to an independent specialist. There are a great many people owning small plants who will be reluctant to engage a specialist for the small installation necessary for their works, and for such people this report will be a boon. It is an excellent example of the good work that can be done by such a body as the Syracuse Chamber of Commerce, when it sets about it in the right way and takes plenty of time to do the work thoroughly and impartially.

Notes and Comments.

THE CREDIT MAN in business organizations has become a particularly important man these days, and because of the talk going on about over-expansion of business there is danger that, by over-conservative judgment, he may cause his associates to lose some good things. A pretty careful study of reports received by this journal during November, coming from all parts of the country, indicates that there is a very large amount of work fairly certain to be undertaken during the coming year. There is likely, however, to be some change in its character as compared with that undertaken at the beginning of this year. The anti-railway laws in the South have shut down railway improvements there, but more municipal work seems likely to be undertaken. A good many manufacturing companies which have recently reported improvements to be undertaken by them have apparently determined to confine this work more to equipment and reconstruction than to new buildings. The work that will be done will be carried out for responsible people of ample resources, who will take advantage of every flurry that lowers prices to secure whatever they need at favorable rates. The flighty promoter will not have much support and he will not be in evidence. Under such conditions, the credit man who is too conservative hurts his associates and his community. There is a large amount of engineering work greatly needed, there is plenty of money for it, and the only obstacle is the tendency to be too suspicious. It has been stated before in this journal, and this statement has found general approval, that it is highly desirable for the sound business men of every community to get together in an association for mutual help. It has been pointed out that such an association can be of great aid financially in a community where the banks are not rendering the service they should. An equally valuable help can be afforded by maintaining a central credit bureau. This has been done for years by merchants in New England cities; in the largest cities bitter commercial rivals exchange information concerning the financial standing of appli-

cants for credit. A good deal depends now on giving all credit that is reasonable for engineering and industrial enterprises, and for this reason a closer association and supervision of the work of the credit man seems desirable.

THE LONDON WATER SUPPLY is the subject of an unusually interesting report made public last month by the Water Board of the metropolis. Some years ago, when the existing works were under private ownership and the London County Council thought it would be a good thing to build a great system drawing a supply from Wales, there was a lack of harmony concerning the course most desirable to pursue. Since then the works have passed under the control of a single commission, which has been studying carefully the needs of the future and the means of meeting them. The report states the results of this study. Primarily it is based on the utilization of the Thames by storage and filtration until the cost of works for the purpose becomes greater than the cost of works to bring water from Wales. This decision is a gratifying recognition of the resources of sanitary engineering. It was not so long ago that the idea of utilizing river water, even when filtered, would have been regarded with grave doubt, but we now know that storage and filtration will furnish a good supply from the Thames unless it should be polluted far more than is now the case. Such an increase in pollution is extremely unlikely. The amount of water used daily in the district is now about 225,000,000 imp. gal., of which nearly 129,000,000 gal. are from the Thames and the remainder are from other sources which cannot yield more than 120,000,000 imp. gal. when fully developed. The average daily flow of the Thames over Teddington Weir in the driest year is 900,000,000 imp. gal., so that a large amount of water can be diverted from it. A study of the probable growth of the population to be served and its consumption of water indicates that in 1916 the storage should be 37 gal. for each gallon of average daily supply, in 1926 it should be 72 gal., in 1941 it should be 91 gal., and about 1960 it should be 120 gal. With such an amount of storage 450,000,000 imp. gal. can be utilized from the river at a lower total expense than water will cost from other sources. The Thames is capable of furnishing a larger quantity than that, but the expense of the additional storage renders any further development of the works undesirable. The population served at that date is estimated at the enormous total of 16,286,000 people, who must be furnished 35 imp. gal. per capita daily, 1.5 gal. more than the present consumption. The astounding thing about the project to the American engineer is the belief of the Water Board that all these great works can be built out of its revenues. Evidently the American plan of paying for such things with the proceeds of bonds and thus charging their expense to the taxpayers instead of the consumers is not regarded with favor. Another feature of the report is the admirable foresight shown in the recommendation to acquire a tract in Wales large enough to meet the requirements for the additional water in the last four decades of this century. The principality does not look with favor on the appropriation of its water, and it will be far less expensive and troublesome to acquire the needed territory now than fifty years hence. The investment will not be entirely without returns, moreover, for by forestry and the lease of the land for grazing and agriculture interest charges on the investment can probably be considerably reduced. It must be gratifying to the people of the British metropolis to have such a satisfactory forecast of future possibilities as the Water Board and its engineer, Mr. Bryan, present in this comprehensive and convincing report.

A GRAVITY WATER SUPPLY SYSTEM AT GREELEY, COLO.

A municipal gravity water-supply system, which embraces various special features of arrangement and design has recently been placed in service at Greeley, Colorado. Greeley is a city of about 7,500 inhabitants, 52 miles north of Denver on the eastern slope of the Rocky Mountains, and is surrounded by an extremely productive agricultural region, although the mean average rainfall in this locality is only a little more than 14 in. a year. The great productivity of the surrounding country is due to the fact that, almost without exception, the land is under irrigation. Water for irrigation is diverted from streams which have their source in springs, or in the almost perennial snow fields in the mountains, the foothills of the latter being about 30 miles west of Greeley. The largest of these streams is the Cache La Poudre River, the principal tributary of the South Platte River, the normal and minimum flows of the former being, in fact, greater than those of the main stream. The waters of the Cache La Poudre River, and of its tributaries, with the exception of a part of the extreme flood flows, are entirely appropriated for irrigation ditches which have their headworks above Greeley. Consequently, the only flow in the river at the latter during dry seasons is the seepage water which finds its way back into the stream from the irrigated lands.

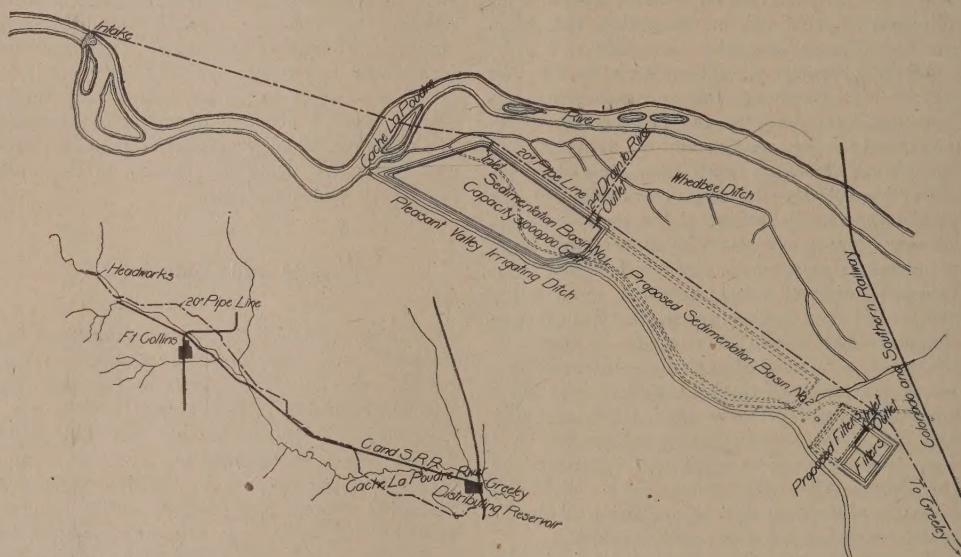
Until the new gravity system was placed in operation, the water supply for general consumption in Greeley was derived from an infiltration well built in the gravel bed of the river a short distance above the business section. The distribution mains were operated under direct pressure from pumps in a station on the river bank adjacent to the galleries, a 14,000-gal. tank on the hill above the city maintaining the pressure during maximum consumption. The supply thus obtained and delivered was not only exceptionally poor in quality, but was also quite limited in quantity during certain seasons. The water which seeps back into the river from the irrigated lands is very highly impregnated with alkali salts of various kinds, a hardness of 1,800 parts per 1,000,000 being common to it. These salts impart a decidedly objectionable taste to the water and actually render it harmful. At the same time, the greatest defect of the water for domestic purposes is the extreme hardness. The water in the river at Greeley is also very deleterious to boilers, and was entirely unsuited for other commercial uses. The infiltration well was practically ineffectual in reducing the extreme hardness, although the turbidity which occurs in the river water under certain conditions was removed by it.

Notwithstanding this extremely unsatisfactory water supply, the local geographic and hydraulic conditions rendered the provision of an adequate quantity of good water an undertaking of exceptional magnitude for the comparatively small community to be served. Ground water from deep drilled, or bored wells in the vicinity is generally good, but the quantity to be obtained in this manner is limited. No possibility, therefore, of obtaining an adequate supply from wells existed. As the Cache La Poudre River and its tributaries are the only permanent streams within a reasonable distance of Greeley, it was evident that the only available supply of surface water to be obtained was from this river. The land is irrigated on both sides of the river above Greeley to the foothills of the mountains, so in order to secure a supply free from seepage from these irrigated lands the water had to be taken from the river in the foothills, at least 36 miles from Greeley.

While the location of the only satisfactory source of supply was thus determined within

relatively narrow limits, other conditions of an exceedingly serious nature had to be met. Since the difference in the value of water rights in the eastern and western sections of this country, or more properly between the humid and arid regions, is so great, and because of the almost sacred character attached to such rights in a section in which irrigation is well advanced, the conditions which were presented will be treated in considerable detail. The appropriations of the entire flow of the river, up to and including part of the storm-water run-off, have become, under decrees of the courts in the order of their application to actual use, vested rights of great commercial value, due to the intense agricultural development of the river valley. These rights are, consequently, guarded with the utmost jealousy by the individual farmers who own them, and any infraction of them, or interference with their rank and precedence in priority is subject to opposition and protest of formidable character. From these conditions, the acquirement of a

diversion from the intake of the ditch to a point some 3,000 ft. upstream in order to locate advantageously an intake for a pipe line leading to Greeley. Furthermore, the quantity of water decreed for irrigation purposes had to be transferred to a right for domestic and sanitary uses. The legal processes of both such transfers frequently meet with strenuous opposition from other water-right owners. The mere diversion of a quantity of water from one to another point of the river may adversely affect the established rights in the intervening section. Besides, the use of water for domestic purposes is essentially more imperative in its demands than for irrigation purposes. It also covers the full year, while water decreed for irrigation purposes may be limited in right to the irrigation season, extending from April 15 to November 15. These transfers were nevertheless made by the court, so the appropriation granted to the ditch placed fourth in the order of priority, and permits the diversion of the water at the desired point. Less than 50 cu. ft. per second have been decreed to other ditches ahead of this one and as the flow of the



Map of Pipe Line and Arrangement of Headworks.

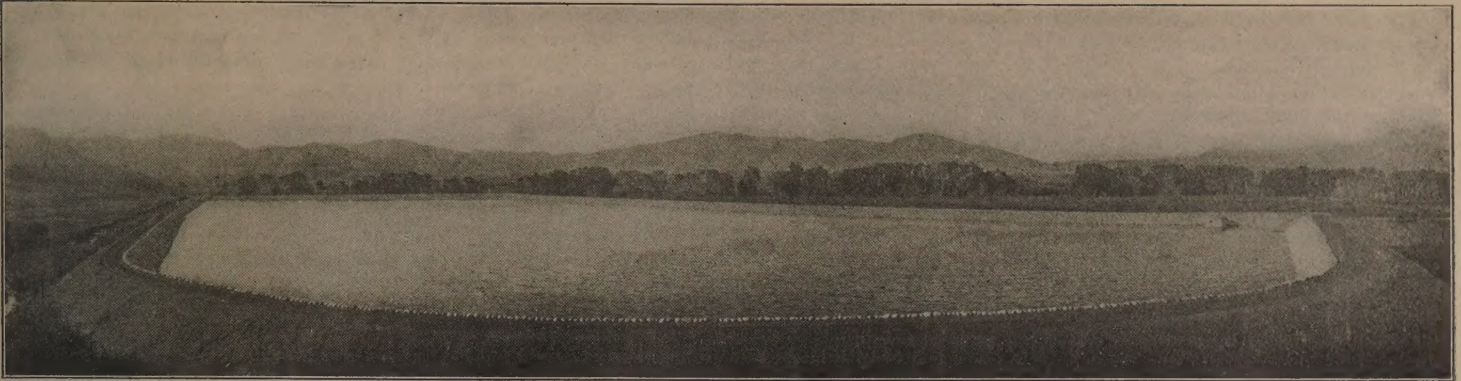
legal right to an adequate water supply at all seasons of the year and at all stages of the river, formed for Greeley, as it must do for all other towns and cities in an arid region where a great irrigation development exists, a most serious problem. In this instance, however, the requisite rights were obtained at a nominal cost and without conflicting with other appropriators.

In the purchase of a site on the river at the edge of the foothills, a portion of the land acquired conveyed with it the title to an irrigation ditch built from the Cache La Poudre River in 1862, which makes it one of the earliest ditches constructed in the valley. This ditch had been used continuously for irrigation purposes from the time it was built practically to the time it was purchased by the city, and it had a carrying capacity of about 7.5 cu. ft. per second. The ditch did not, however, possess a legal existence, so far as the records of appropriations decreed by the courts showed, although it had a right to a supply of water from the stream, because the formality of presenting a claim, or statement of its standing and of having the appropriation of its right decreed by the courts had been neglected. The state laws of Colorado contemplate the correction of such omissions, however, on due notice to all parties concerned in the water appropriations. Accordingly, when the claim was properly presented the decree for the ditch was entered as August, 1862, with an appropriation of $7\frac{1}{2}$ cu. ft. per second. It was then necessary to transfer the point of

river is rarely, if ever, less than that quantity, a supply is assured at all times. The quality of the supply is also excellent. The normal total hardness of the water is only 40 parts per million, as compared with the 1,800 parts per million in the original supply of the city; the normal bacterial content is remarkably low, and during almost the entire year turbidity and color are absent. The value of a supply of this character to a community in the semi-arid region in which it has been obtained is scarcely appreciated in sections of the country where water is plentiful and quality of the supply is the chief consideration.

A 20-in. wood-stave pipe line, 36 miles long, has been built to deliver the water to Greeley from an intake in the river near the head-works of the old irrigation ditch. In connection with this pipe line, a 31,000,000-gal. storage and sedimentation basin and two 1.25-acre slow-sand filtration basins have been built a short distance downstream from the intake. A 5,000,000-gal. receiving and distributing reservoir has also been built on a hill, two miles from the city. Sites have also been reserved for a second sedimentation basin of over twice the capacity as the existing one for doubling the filtering area and for a second receiving and distributing reservoir. Provisions for connections for these proposed additions have been made along with the present work, to facilitate future construction.

The ultimate capacity of the pipe line of the new system is 5,000,000 gal. per day, while the



The 31,000,000-Gallon Sedimentation Basin.

normal average daily consumption in Greeley is now about 1,250,000 gal. In the design it was planned to provide for a population of 15,000, with a per capita consumption of 300 gal. This allowance is not unusual in cities and towns in the arid or semi-arid regions where lawns, trees and all vegetation is wholly dependent on irrigation. The construction of the new system along these lines and the acquisition of the water right described, make ample provision for the growth of the city.

The intake of the pipe line is only half a mile downstream from the mouth of the canon of the river in the foothills. About six miles above this intake the river divides into two branches, the North, and the Main Forks. The water from both forks is normally clear and cold, since the source of both is springs and snow-fields in the mountains. Under certain rainfall and flood conditions, however, the turbidity of both streams is pronounced for short periods. The turbidity which occurs is due to the washing of the light soils in the watersheds and is remarkably difficult to remove by sedimentation. The conditions which cause it frequently occur on different occasions in the watersheds of the two forks, so the water from one fork may be clear when that in the other is fouled.

The normal bacterial content of the water of the river above the intake is unusually low, due largely to the fact that little or no land on the watershed is cultivated and the resident population is extremely scant. On the other hand, much grazing land exists in the catchment area of the river and large numbers of camping parties frequent the mountains in this locality during the summer. Consequently, in designing the works the waters of both forks of the river were considered to be liable to immediate dangerous contamination, under certain conditions, and to more frequent contamination in the future.

Under these circumstances, the storage and sedimentation basin and the slow-sand filters

were provided, in order that a uniformly clear, pure water might be delivered to the city. The only other alternative to these works would have been to extend the pipe line six miles up the canon to the junction of the two forks of the river, so water could be taken from the Main Fork only, which prior to the construction of the new works was considered to be free from turbidity, although subsequent observations have disproved this. Such an extension would have cost quite as much as the works that have been built, owing to the difficult and expensive character of the construction work required to make it. Moreover, the supply would have still been subject to periods of turbid water and to the possibility of dangerous contamination. The storage and sedimentation basin that has been built has sufficient capacity to supply the system, during the short periods when the turbidity of the river is the worst, without requiring any water to be drawn from the river during these periods. It also has enough capacity to permit a considerable percentage of the bacteria as well as the rarely occurring turbidity, to be removed by sedimentation. The slow-sand filters have already demonstrated that they will reduce the bacterial content well within what is considered a safe limit for a domestic supply.

Headworks. A loose-rock diverting dam, 6 ft. high and 10 ft. wide on top, has been built across the river at the intake where the width of the stream channel is about 125 ft. The bed of the channel in this vicinity is gravel and small boulders. The latter and a quantity of broken rock, in pieces containing from 2 to 6 cu. ft. each, were used in making the dam, the downstream face being built on a slope of about 5 to 1 and the upstream face 1 to 1. The dam was made only tight enough to raise the stream level above it, in order that water might be diverted into the intake. The loose-rock construction has already been subjected to as nearly severe flood conditions as may be expected to occur, without

material damage, and it is considered to be as well adapted for the service required as a more expensive masonry structure.

The intake to the 20-in. wood-stave pipe line is simply a concrete chamber at one end of the diverting dam, with an opening, protected with a rack screen, connecting it with the river. A manhole is provided in the top of the chamber so that the latter may be entered. A vent is placed in the pipe line just below the intake to permit the escape of air that enters the line at the latter.

The pipe line is on the right bank of the river for about half a mile from the intake, and then crosses the river at a wide place in the channel of the latter, close to the upper end of the sedimentation basin. This first part of the pipe line involves no special features of construction, except the river crossing was made with cast-iron pipe.

Sedimentation Basin. The sedimentation basin and the filters are along the foot of a high hill, between the river and an irrigation ditch, which has its intake at the upper end of the sedimentation basin and skirts the base of the hill. The sedimentation basin was built to fit the ground, so is irregular in plan, its extreme width being 500 ft. and extreme length 1,400 ft. It is partly in excavation and partly in embankment. The embankments are 20 ft. wide on top, have a 1½ to 1 slope on the outer faces and a 2 to 1 slope on the inner faces. They were built with material from the excavation, which was hauled into place by teams and scrapers. The inner slopes are protected with hand-laid rip-rap, consisting of small glacial-drift boulders. The basin is not otherwise lined, but is practically water-tight. The outer slope of the upstream embankment is liable to wash during flood flows, so it is well protected with a layer of rip-rap of fair-sized boulders, the top of the embankment being placed 5 ft. above the highest known flood level, which occurred in 1904.



Receiving and Distributing Reservoir with Concrete Columns Ready for Wooden Roof.

The 20-in. wood-stave pipe line extends along the river side of the basin, close to the toe of the outer slope of the embankment on that side. An inlet connection to the basin from the pipe line is made at the outer, upstream corner. This connection is a 20-in. cast-iron pipe, laid under the embankment to a point 40 ft. inside the inner slope, and is provided with a gate valve so the flow in it may be controlled. The outlet from the basin is through a riser in an 8-ft. circular concrete chamber, in the downstream end of the basin, close to the inner toe of the slope of the embankment on the river side, the bottom of the basin sloping to this corner. Water can be drawn into the riser in the outlet chamber through four 20-in. connections, all at different levels, one of these is at the bottom and permits the basin to be drawn down entirely; the second is 8.5 ft. above the bottom; the third 6 ft. above the second, and the fourth is an overflow, which prevents the depth of the water in the basin becoming more than 16 ft. at the outlet. Each of the three lower connections is provided with a gate valve in the chamber. The connection between riser in the chamber and the 20-in. wood-stave line has a valve in it near the junction with that line; a valve is also placed in the latter near this connection. The arrangement of valves permits the basin to be by-passed, if desired, or the flow in the pipe line above the basin may be cut off and the supply drawn from the basin. The reservoir can also be drained by a 24-inch sewer leading to the river.

The site for the second sedimentation basin is immediately down stream from the first, the two basins being arranged, in fact, to have a common embankment at their adjacent ends. The two filters that have been built are 800 ft. downstream from the lower end of the proposed sedimentation basin, space being left on their upstream side for the two proposed additional filters and for the house and grounds of the attendant who is in charge of the filters and head-works.

Filters. The two filters which have been built are in a single open basin, 210 x 330 ft. in plan at the top, which is formed partly in excavation and partly by embankments. The embankments are 20 ft. wide on top and have both faces on a slope of $1\frac{1}{2}$ to 1. The inner slopes of the embankments and the bottom of the filters are lined with 6 in. of concrete. A reinforced concrete division wall on the transverse center line of the basin separates the latter into the two independent filters, each with a filtering area of 1.25 acres. No covering was provided for the filters, as many years' experience in the operation of the open slow-sand filters of the Denver Union Water Co., at Denver, Colo., under climatic conditions very similar to those existing at the filters of this system is considered to show that the reduction in cost of operation produced by the covers, under the existing conditions, would not have justified the increased cost of such construction.

The operation of the filters is controlled from a 20 x 20 ft. concrete gate chamber built in the embankment, at the upstream end of the division wall. This chamber is surmounted by a substantial brick house of quite satisfactory appearance. The chamber contains all the necessary inlet, outlet and drainage connections for the two existing filters, and for the two proposed additional filters as well. The 20-in. wood-stave pipe line extends along the river side of the filters and has two 20-in. lines leading from it to the gate chamber, one for an inlet and one for an outlet. Both of these lines are cast-iron pipe

laid under the embankment, which will be common to the two existing and the two proposed filters, when the latter are built. The inlet has two tees inserted in it in the gate chamber, with four 20-in. inlet connections, one for each filter, provided in these tees. As in all of the connections for the two proposed additional filters, the inlets provided for the latter are fitted with blank flanges. Each inlet connection is fitted with a gate valve and ends in an open chamber in the adjacent corner of the filter, the sides of this chamber being carried above the sand level in the filter. Four connections to the 20-in. outlet are provided, one for the underdrainage system of each filter; these connections are arranged in the gate chamber the same as the inlet connections.

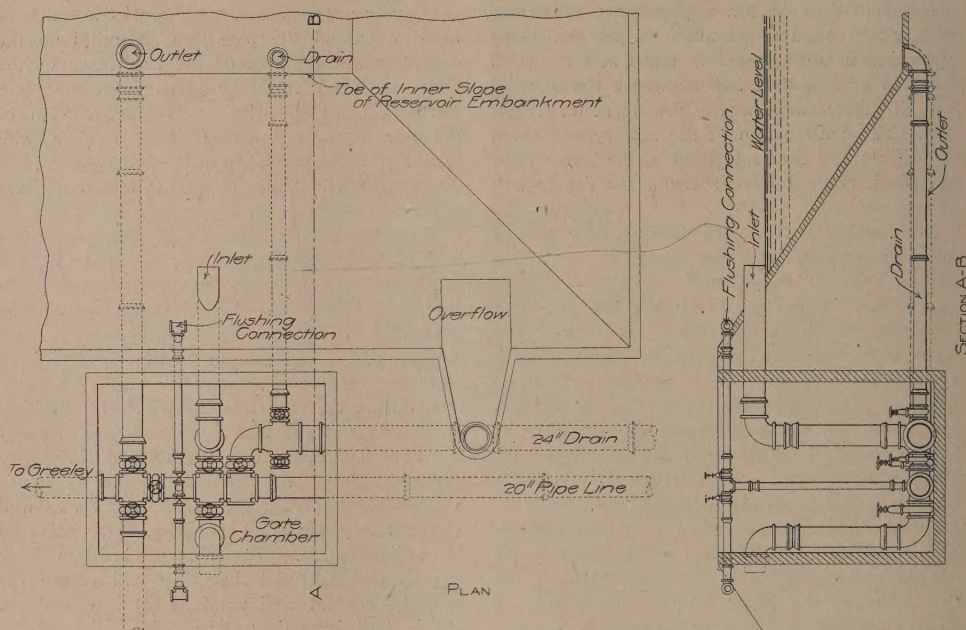
A 12-in. drain leads from the gate chamber to the river. A 6-in. connection to this drain for each filter permits the water over the sand in the

centage of carbonates contained in the water to be low, as might be expected, since the river water is practically free from salts at this point.

Mechanical Analyses— Mean Diameter.	Sample 1. Per Cent.	Sample 2. Per Cent.
Less than 0.13 m.m.....	0.125	0.034
Between 0.13 and 0.27 m.m....	0.590	0.235
Between 0.27 and 1.00 m.m....	89.585	82.731
Between 1.00 and 5.00 m.m....	9.700	17.000
Over 5.00 m.m.....	0.000	0.000
Total	100.000	100.000

Chemical Analysis to determine Carbonates—	Per cent.	Per Cent.
Lime (as carbonates).....	0.42	0.36
Magnesia (as carbonates)....	0.064	0.112
Total carbonates	0.484	0.472

The 6,800 cu. yd. of gravel and sand in the two filters were hauled about a mile from the river in wagons. The gravel was screened by hand, and the sand and gravel were washed in a flume, the same as gold was formerly washed



Connections at Receiving and Distributing Reservoir.

filters to be drawn off. An overflow connection to the 12-in. drain from each filter prevents the water in the filter exceeding a depth of 6 ft. above the bottom.

The underdrainage system of each filter consists of a 24-in. main drain, on the longitudinal center line of the filter, with 6 in. lateral drains. These drains are all vitrified sewer pipe, laid with open joints. The lateral drains are 14 ft. apart and extend to within 3 ft. of the sides of the filter. The end of the main drain distant from the outlet end is 0.7 ft. higher than the latter end, and each lateral has a fall of 0.4 ft., insuring drainage.

A minimum depth of 3 ft. of filtering materials is placed over the underdrains, 1 ft. of gravel at the bottom surrounding the underdrains, with 2 ft. of sand over it. Washed gravel from the river was found to be entirely satisfactory for the purpose. The gravel in the lower 7 in. of the 1-ft. layer was required to remain on a screen with 1-in. meshes, but to contain very few stones over 2 in. diameter. Over this coarse gravel is a $2\frac{1}{2}$ -in. layer of gravel, which will pass a screen with 1-in. meshes, but he retained on one with $\frac{3}{8}$ -in. meshes. The gravel in the remaining $2\frac{1}{2}$ in. would all pass a screen with $\frac{3}{8}$ -in. meshes, but is coarser than ordinary sand, and free from fine material. Sand of excellent character was also obtained from the river. Two mechanical analyses of this sand are shown in the accompanying table, from which the high coefficient of uniformity is evident. Chemical analysis made of the same samples showed the per-

centage of carbonates contained in the water to be low, as might be expected, since the river water is practically free from salts at this point. In placer mining. A permanent incline, built in one corner of each filter, permitted the washed gravel and sand to be hauled into the filters in wagons, but it was found more advantageous and equally satisfactory to dump the materials over the sides of the embankment and to distribute them by wheel barrows. The inclines are intended for use in removing the dirty sand scraped from the filters and in replacing clean sand, as it was impracticable to install mechanical sand handling apparatus.

The head-works of the supply system, including the filters, are operated by an attendant who has had long experience in the work of this character, and lives in a house provided, adjacent to the filters, by the city. The experienced attendant, at a salary somewhat in advance of the amount for which an inexperienced man could be secured is an unusual procedure in the management of municipal works of the character and size of these, but the slight additional cost has already proved a profitable investment, as more uniform results from the filters and lower maintenance charges are thus assured.

The filters were placed in operation on Sept. 4, last, but the results of only a single series of tests to determine their bacteriological efficiency is available. Three samples of water taken from the inlet to the filters on Nov. 3 showed, after four days plating, 310, 320 and 335 colonies per cubic centimeter, respectively, while two samples taken from the effluent the same day developed only 38 and 47 colonies, after four days' plating. From this test the efficiency of the

filters was 86.79 per cent. In considering this efficiency it must be borne in mind that the bacterial content of the raw water is unusually low and that the water was practically free of sediment at the time. From Sept. 8 to Oct. 30, inclusive, a bacteriological analysis of the water delivered from the tap in the city was made each alternate day. An abstract of the results of these analyses is shown in the accompanying Table 2, from which the uniformly small number of bacteria is evident. The rather large number of bacteria from Sept. 8 to 16 inclusive, is considered



Hauling Wood-Stave Pipe.



Typical Section of Pipe Trench.

a temporary frame structure, 40x125 ft. in plan. The equipment in it was all motor driven, thus greatly reducing the danger from fire. The staves were cut to shape from the square timbers by two planers, which also formed the tongues and grooves on the edges. The finished staves were placed in an accumulating machine, in which they were formed into the pipe lengths, and the ends of the lengths cut square and turned on the outside. The continuous bands were then wound on the lengths by another machine. The complete pipe lengths were finally delivered to a tank outside the building, in which they were dipped to receive an asphalt and tar coating, applied to protect the bands.

The location of the pipe line greatly simplified the delivery of the pipe from the factory to the trench, since the maximum haul from a railroad station at any point on the line was not over 2 miles. The pipes were hauled from the various railroad sidings to the work on ordinary four-wheel wagons, a single team being able to draw seven to nine 16-ft. sections at a load. Care was taken after the pipe left the factory to prevent injury to the coating, and after the pipe was in place all bands on which the coating had been injured were painted with asphalt and tar.

The pipe trench was made uniformly 30 in. wide and 4 ft. deep. With the exception of about 2,000 linear feet of rock work, the excavation

to be due to the sediment and impurities in the pipe line and other parts of the new system.

TABLE 2.—COLONIES PER CUBIC CENTIMETER IN TAP WATER IN GREELEY.

Date.	48 hrs. 96 hrs.	Date.	48 hrs. 96 hrs.
Sept. 8	750	Oct. 7	68 184
Sept. 10	625	Oct. 9	77 191
Sept. 12	568	Oct. 11	64 185
Sept. 14	500	Oct. 13	81 217
Sept. 16	200	Oct. 15	68 206
Sept. 18	76	Oct. 17	52 173
Sept. 20	118	Oct. 20	29 125
Sept. 22	80	Oct. 21	43 109
Sept. 24	73	Oct. 23	57 203
Sept. 26	61	Oct. 25	49 181
Sept. 28	58	Oct. 27	46 194
Oct. 3	65	Oct. 30	41 189
Oct. 5	52		165

Pipe Line. The country drops away gradually towards Greeley from the filters, the latter being 340 ft. above the receiving and distribution reservoir, but the topography is rough and broken in many places. Considering this rough nature of the country, the pipe line has an exceptionally straight alignment and very satisfactory grades. In general, the line follows down the valley of the Cache La Poudre River. To within 8 miles of Greeley, it is up along the base of hills which skirt the right side of the valley, and then crosses the river and continues on the left side of the valley to Greeley. From the head-works to this crossing of the river, 8 miles from Greeley, the pipe line takes a nearly direct course and is laid on a remarkably smooth, even grade, with few special features, except the crossings of several streams and irrigation ditches, at which crossings cast-iron pipe was used. In crossing from the right to the left-hand side of the river valley, advantage was taken of a low divide on the left side of the valley which permitted the higher ground on that side to be reached. From this crossing to the receiving reservoir the country is particularly broken and hilly, but even under these adverse conditions a comparatively straight line, with few abrupt grades, was secured.

Automatic air valves are placed at summits in the line as required, and blow-off valves and connections at convenient low points. At a point about three miles from the receiving reservoir where the pipe rises to within 12 ft. of the hydraulic grade line a section of 20-in. pipe was placed on the line as a surge chamber.

Machine-banded wood-stave pipe was used for the entire line, except at stream crossings and the connections to the reservoirs and basins, for

which crossings and connections cast-iron pipe was used. The staves were cut from Douglas fir, free from all defects that would impair their strength or water tightness, and were at least 1 3/8 in. thick when put into the pipe. The edge of the staves were planed to true radial lines and then cut so as to form a double tongue and grooved joint between each two staves. The pipe is banded with double-galvanized wire, having a tensile strength of not less than 60,000 lb. and not more than 70,000 lb. The wire was spaced on the pipe according to the following formula:

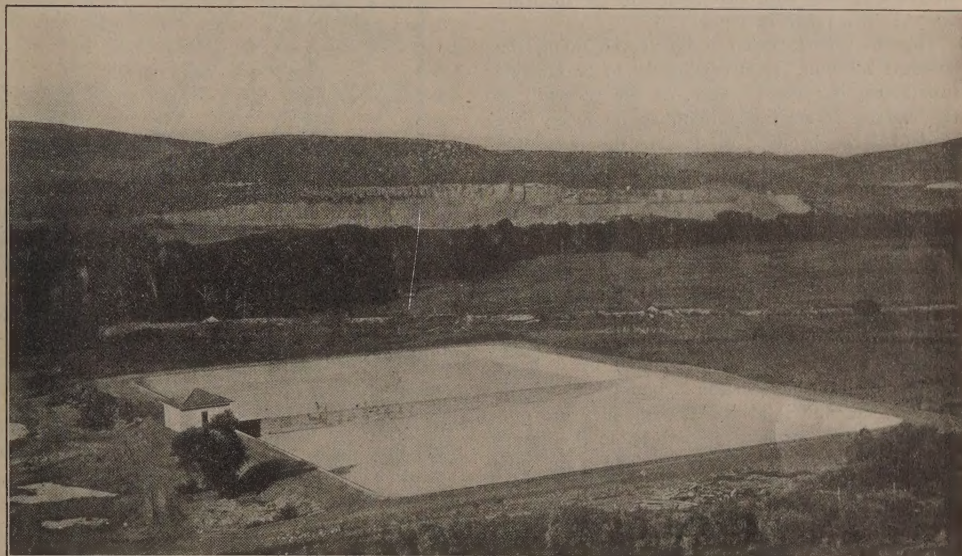
Spacing in inches = $43000d^2 \div DH$, in which d = diameter of the wire, D = diameter of pipe and H = head on the line in feet. The maximum spacing under any conditions was 3 in., and No. 4 Washburn & Moen's gauge wire was the smallest used.

The pipe was made in 6 to 16 ft. lengths, over 50 per cent. of the lengths being at least 10 ft. long. The lengths were sawed square at the ends and turned smooth on the outside for a width of 4 in. from each end, to provide for the couplings used. These couplings are of wood-stave pipe, each 8 in. long, and are made just large enough to fit snugly over the turned ends of the pipe lengths. They are banded, with a factor of safety twice that of the pipe, with individual round wires not less than 1/2 in. in diameter, and of the same tensile strength as the banding of the pipe.

The lumber for the pipe was shipped to Greeley from the State of Washington in 2x4-in. and 2x6-in. sticks of varying lengths, the pipe being made in a factory built in connection with the work. This factory was erected close to the railroad in Greeley, in order to facilitate delivery of the pipe to the line. The factory building was

was made with a Buckeye traction ditching machine. This machine worked to great advantage and greatly increased the speed and reduced the cost of the trenching. For nearly 7 miles from the intake of the pipe line, the trench was almost continuously in a stratum of gravel, containing numerous small boulders, with much of the gravel of a cementing nature. The balance of the trench, however, was mostly in hard clay, with the exception of about a mile of gravel and boulders near the receiving reservoir. The ditching machine dug from 600 to 1,000 ft. of trench in a 10-hr. day in the gravel and boulders, an average day's run in such materials being about 800 ft. In the clay and other soils the machine frequently finished 2,500 ft. of trench in a day, 1,600 ft. being normally dug under such conditions. Since the machine requires only four men to operate it, the cost of the trenching was very low. In fact, the contract price was only 9 cents per linear foot, but at least a fair profit was made at that very low price.

Receiving and Distributing Reservoir.—The 5,000,000-gal. receiving and distributing reservoir on the hill above the city is 224 ft. square in plan at the bottom, and is built in excavation and em-



The Two Slow-Sand Filters.

bankments. The tops of the embankments are 16 ft. above the bottom of the reservoir and are 20 ft. wide on top, with $1\frac{1}{2}$ to 1 slopes on both sides. The inner slopes of the embankments and the bottom of the reservoir are lined with 6 in. of concrete.

In order to exclude sunlight from the filtered water, and thus prevent growths of obnoxious algae in the reservoir, the latter was covered with a flat wooden roof carried by concrete columns. These columns are in regular transverse and longitudinal rows, spaced 14 ft. apart on centers in one direction and 18 ft. in the other. They are 18 in. square at the base, $12\frac{1}{2}$ ft. high and 6 in. square at the top. Each column stands on a square pier, independent of the concrete lining of the bottom, and is reinforced with two vertical $\frac{1}{2}$ -in. Johnson corrugated bars. Although these columns have a comparatively small cross section, they were quite readily built by making the forms in two parts, an upper and a lower, and casting the lower 6 ft. of the columns before the top sections of the forms were placed.

The wooden roof has 6x6-in. timber girders, spaced 14 ft. apart on centers on the transverse rows of columns, with 2x8-in. joists, 4 ft. apart, in the opposite direction. The joists are braced together by a row of 2x4-in. bridging between each two girders. The flooring consists of 1x10-in. by 16-ft. roofing boards. The roof contains, alternately, one and two 30-in. by 16-ft. trap-doors in the 14x18-ft. bays.

This roof cost \$6,000 complete, including the concrete columns. It is considered to be entirely satisfactory for the purpose, as the snowfall in the vicinity is relatively light, so no heavy live loads will be brought on it. As the maximum level in the reservoir is 1 ft. below the lowest part of the roof, and as no covering is to be placed over the roof, the lumber may also be expected to last a long time in the dry climate.

The additional receiving and distributing reservoir, which it is proposed to build when required, will be at one end of the present one, the two having a common end embankment. An 18x18-ft. concrete gate chamber, surmounted by a brick house, has been built in the incoming end of this embankment and is arranged with inlet and outlet connections for both reservoirs, so the future work will be greatly simplified. The 20-in. pipe line from the head works is laid longitudinally under this embankment, passing through the bottom of the gate chamber. Two tee connections are placed in the pipe line in the chamber, providing for an inlet and an outlet for each reservoir. Each of these inlets and outlets is fitted with a gate valve and the pipe line has a gate valve between the two tee connections, so water may be passed through either reservoir, or both reservoirs by-passed. The inlet to the reservoir delivers into a 2x3-ft. flume, 12 ft. long, which is suspended from the reservoir roof, close to the gate chamber. The outlet is connected to a sump in the bottom of the reservoir just outside the inner toe of the slope of the embankment. An overflow is provided so the maximum depth of water in the reservoir will be 12 ft. At this depth the water surface is 176 ft. above the central part of Greeley and produces 60 to 70 lb. pressure at the fire hydrants in the city.

The pipe line is connected in the gate chamber with a 20-in. waste pipe leading to an adjacent irrigating ditch, so it can be drained. An 8-in. connection to this waste pipe is also provided for each reservoir in the gate chamber. This connection ends in a sump in the bottom of the reservoir, so the reservoir may be drained. A standpipe, consisting of two sections of 20-in. cast-iron pipe, was placed on the pipe line near the gate chamber, in order to provide sufficient head to flush the reservoir when the latter is empty.

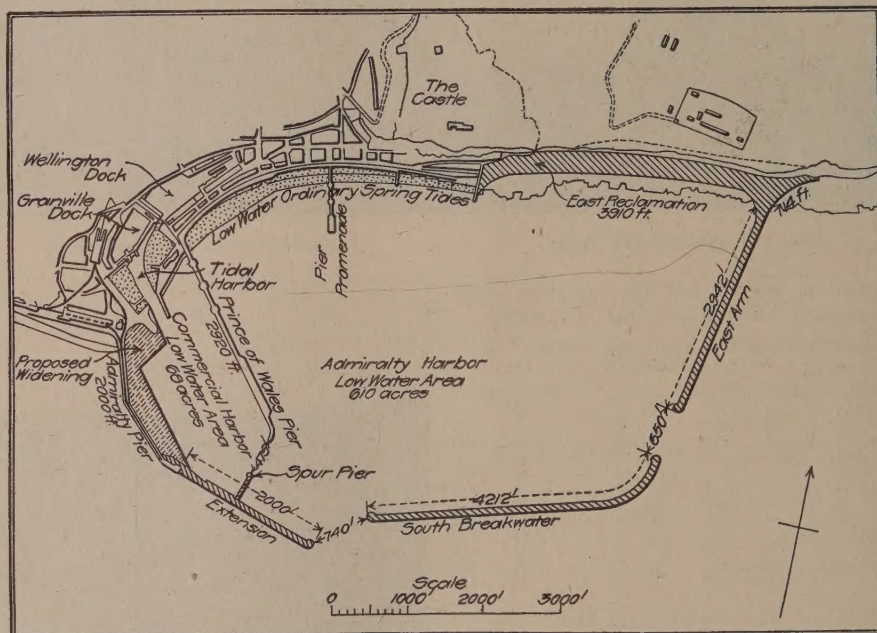
A 6-in. connection to the pipe line is made in the gate chamber and is carried into the reservoir, where it connects with three lines of 2-in. pipe extending across the reservoir with hose connections at suitable intervals.

The new water supply system for Greeley, which has been described herewith, was designed by Mr. George G. Anderson, consulting civil and hydraulic engineer, of Colorado, and was built under his supervision by The Jacobson Bade Co., of Portland, Ore. The City Council of Greeley, to whom credit is largely due for the adoption of the various modern features of the system as suggested by the engineer, are as follows: Mr. F. J. Green, mayor, and Messrs. F. M. Barber, A. W. Jacobs, J. B. Phillips, C. H. Ward, D. H. Strohl and W. C. Wilson, of which Messrs. Wilson, Phillips and Ward were the water-works committee. The Pacific Coast Pipe Co., of Bal-

The Harbor Works at Dover, England.

By C. O. Burge, M. Inst. C. E.

A few months ago reference was made to these works in an article, more especially in connection with the proposed Channel Ferry, which, as was pointed out, is of special interest, as virtually making Dover a Continental as well as a British port. Atlantic passengers landing there will, when the ferry is established, be able to proceed without further change equally to any part of the Continent as well as Great Britain, and, vice versa, the same considerations applying to freight. In reference to the ferry, a deputation headed by Lord Weardale, the chairman of the ferry company, had an interview on Oct. 24 last with the president of the British Board of Trade, a Cabinet minister, who expressed the warm approval of the government



Harbor Works of Dover.

lard, Wash., furnished the lumber and built the wood-stave pipe. The total cost of the entire system, including all construction, water-rights, rights-of-way, legal expenses and so forth, was between \$360,000 and \$365,000.

THE STADIUM in which the Olympic games will be held next year at the Franco-British Exhibition, London, is now under construction. It is oblong in plan, with straight sides and semi-circular ends, and measures 594x1,000 ft. over all. The arena besides the large turf-covered space for games, will contain a bicycle track 35 ft. wide, a running track 25 ft. wide, and a swimming tank 50x335 ft. The total capacity is about 75,000 persons. Seats are arranged in 32 tiers along the straight sides, while standing room arranged in 65 tiers is provided in the semi-circular ends. The inclined stringers supporting the tiers are of 15-in., 42-lb. I-beams, 20 ft. apart, and are carried by latticed-channel columns, braced longitudinally and transversely. The risers consist of channels fixed to the stringers by means of forged stools. The tiers are of reinforced concrete, averaging 2 in. thick, the steel consisting of indented bars 1-3 in. square, spaced 12 in. apart. Seats of wooden lath are to be fixed to the concrete. On the flat sides the seats are covered by a roof with a span of 61 ft. 8 in., having an overhang of 17 ft. 10 1-2 in. The roofing is of corrugated sheets. The space under the seats will be used for offices, restaurants, and like purposes. There is an open space 10 ft. wide in front of the seats from which numerous entrances are provided.

to the scheme, in preference to the rival one of the tunnel, now set aside. The deputation, besides the chairman, consisted of Sir C. Rivers Wilson, chairman of the Grand Trunk Ry., Canada; Admiral Sir Cyprian Bridge, Colonel Ivor Phillips and the Hon. George Peel. The French authorities were subsequently approached and also gave their approval of the scheme, which we may, therefore, hope to see put in hand at an early date. But apart from this, Dover as a present port of call for an increasing number of Atlantic liners claims our attention, while the British Admiralty have almost completed very large works, in order to make the port a naval base, and their operations are of considerable interest as affording one of the latest examples of harbor construction. Originally there was a commercial harbor only at the extreme west side of the port, consisting of a structure called the Admiralty pier, 2,000 ft. long, sheltering on the west the entrance to the tidal harbor, and the Wellington and Granville docks (see map), there being no shelter from south or east. This accommodated the cross channel traffic for years. So long ago, however, as the time of Sir Walter Raleigh the advantages of Dover as a naval port were recognized by that far-seeing statesman, though it was not till about two and a half centuries after his time, viz., in 1840, that steps were taken by the appointment of a commission to give effect to his ideas. The plans, subsequently improved, have now resulted in the following works:

The Prince of Wales Pier, 2,920 ft. long, dividing the commercial from the future Admi-

rality harbor. This is roughly parallel to the original Admiralty pier and eastward of it and of the entrance to the tidal harbor; secondly, the extension of the latter pier, approximately easterly, to double its original length, making it 4,000 ft. long, and a northeasterly spur from it nearly midway on the extension, towards the head of the Prince of Wales pier, enclosing as the commercial harbor, 68 acres. The mouth of this is 475 ft. wide, facing nearly east, and is protected by the remainder of the Admiralty pier extension. The naval harbor, which has an area of 610 acres, lies to the eastward and is bounded on the west by the Prince of Wales pier and the extension, beyond the spur, of the addition to the original Admiralty pier; and on the east by a pier springing from the shore about $1\frac{1}{2}$ miles east of the Prince of Wales pier and running south for 2,942 ft. The harbor is protected from the south by a breakwater extending from near the end of the pier just mentioned to within 740 ft. of the head, on the west, of the Admiralty pier extension. The gap between the east pier and the breakwater, 650 ft. wide, forms the eastern entrance. The breakwater is 4,212 ft. long and is so aligned as to finish westerly somewhat nearer to the shore than the pier head of the extension, so that the western 740-ft. entrance is partly sheltered from the west.

The government works also include a reclamation, 250 ft. wide, extending for 3,910 ft. from the foot of the cliffs on which the ancient Dover Castle stands, dominating, in the center, the whole harbor, to the root of the east pier. The depth of water at low water is only from 14 ft. to 19 ft. within 1,000 ft. from the coast line, increasing to from 30 to 40 ft. within a further belt of 1,000 ft., so it will be seen what increased accommodation will be afforded by the works outlined above. The "Dreadnought" and battleships of even greater size can be berthed alongside at almost any part of these piers. It is proposed also to connect the east pier, by rail through a tunnel under the cliff, with the railway, some distance inland, which connects Dover with Chatham and Woolwich, the great military and naval arsenals, so that the ships of war can thus be the more readily supplied with material. In conjunction with Sheerness, in the Thames estuary, Dover harbor will form an effective base for British naval operations in the North Sea.

As to the commercial harbor, the Admiralty have hitherto allowed the use, with some necessary interruptions, owing to construction operations, of the northeast side of the Prince of Wales pier for transatlantic service, but it is understood that, in order to make the division between the naval and commercial portion distinct, the transatlantic steamers will berth in the future within the latter division. Quite recently, we understand, an arrangement has been made between the railway company and the harbor board for the erection of a new station and wharf extension at the eastern side of the original Admiralty pier for the better accommodation of the ordinary cross-channel traffic, and though the site for the special landing device for the channel ferry is not yet definitely fixed, it must necessarily be close by.

A bill is to be promoted in the forthcoming session of the British Parliament to obtain powers to build two graving docks at Dover. The larger of the two will be about 950 ft. in length and 110 ft. wide, with a depth of 33 ft. It will be therefore capable of taking the largest ship in the British navy.

For ocean traffic to or from London and the ports of Northern Europe, Dover possesses, as a port of call, one great advantage in these days of record voyages. Such traffic must, in any case, pass close to the heads of the new harbor,

so that there is no detour, while a call at Southampton entails a considerable one up Spithead and Southampton water at slow speed, while Plymouth Sound also requires a deviation from the direct route. A smaller advantage might be mentioned, that is, that Dover is only about one hour and a half by rail from London, and the terminus there is the most central in that city.

The harbor works, which have been mostly carried out by Messrs. S. Pearson & Son, are chiefly constructed of concrete blocks and granite. The Prince of Wales pier, however, for 1,200 ft. from the shore line, is of iron screw piles, the remainder of its full length of 2,920 ft. being of concrete. We are indebted to "Engineering" for the information on which the following outline of the concrete work is based: The bottom is of chalk and chalk marl, and marl and flint, very tenacious for anchorage purposes, and was considered, after levelling by divers, as a good foundation for the concrete blocks, which are 6 to 1, and range up to 40 tons in weight, the maximum size being 14 ft. by 11 ft. 6 in. by 6 ft. 6 in. high. The bond is formed by the variation in the size of the blocks. Above low water level the work is grouted with 2 to 1 cement mortar and is faced with granite, the face blocks being joggled with 4 to 1 concrete pins fitting into circular cavities in adjoining ones. The faces above low water have a slight batter, below they are stepped, the east pier being 40 ft. above and a maximum of 47 ft. below that level, the widths at top and bottom being 47.6 ft. and 54 ft. Along the seaward sides, there are aprons of 40-ton concrete blocks formed with a curve to dissipate the waves. The retaining wall for the reclamation is also of concrete blocks, and granite facing and coping, with filling in of chalk. The progress in the science of engineering construction is shown by the fact that 80 to 90 ft. per annum was the rate of progress in the original Admiralty pier finished in 1871, while the rate in the new harbor has ranged from 450 ft. to 1,500 ft. per annum.

Messrs. Coode, Son & Matthews, the head of which firm, Sir William Matthews, is at present President of the Institution of Civil Engineers, are the engineers, Mr. A. G. Vaughan-Lee, M. Inst. C. E., being in local charge. Major Sir H. Pilkington, R. E., K. C. B., represented the admiralty from 1895 to 1906.

BELT CONVEYORS are used extensively in the mine headworks of the New Kleinfontein Co., Transvaal. Of the seventeen belts used, the waste system contains five working in succession, the last two on top of a dump 130 ft. high. They handle an average of 1,358 tons of waste rock, sand and ashes per day and are 30 in. wide. The longest is 454 ft. between pulley centers. The second belt runs horizontally in a deep cut for 110 ft., then rises to the surface and continues at an inclination of $19\frac{1}{2}$ deg. to the top of a light steel tower 60½ ft. high. Between this tower and a similar but higher one, 195 ft. distant, the third belt is carried by two inverted bow-string trusses. When the spoil had reached the top of the higher tower a fourth belt was installed and carried on a boom swung from a 60-ft. steel mast. The boom was originally 20 ft. long, but was extended in sections as the dump required, until it reached 140 ft. A fifth belt was then installed. It is carried on a 164-ft. double cantilever of two trusses, supported at the center on a turn-table carriage, which runs on a track 20 ft. from the edge of the dump. By this combination of a swinging boom and a traveling cantilever the discharge end moves in the arc of a circle through an angle of 170 deg., with the mast as the center. The belts are electrically driven, the speeds varying from 275 to 340 ft. per minute.

A Discussion of Smoke Prevention.

The Chamber of Commerce of Syracuse, N. Y., appointed a committee some time ago to conduct an impartial investigation of the ways and means of abating smoke. This committee consisted of Dr. John A. Mathews, chairman, and Messrs. John H. Barr, W. H. Blauvelt, Carleton A. Chase, William Kent, J. D. Pennock and John E. Sweet. This committee has recently made a valuable report on the subject. It has reached the conclusion that in a place like Syracuse the abatement of smoke is desirable on aesthetic and economical grounds rather than one of public health. A study of what has been done elsewhere has also led the committee to the opinion that the passage of an ordinance, no matter how drastic, will not remedy the smoke evil. The enforcement of the ordinance must be rendered unnecessary by the hearty co-operation of steam users. When it can be demonstrated that economics may be effected by improved methods of firing, the enforcement of the ordinance becomes a voluntary act of enlightened self-interest on the part of the manufacturers.

Hand Firing.—The first remedy suggested by the committee for smoky chimneys is proper hand-firing, which seems to be given more attention in Great Britain and Europe than here. The committee points out that an intelligent fireman is worthy of good pay, for many ignorant and careless men doubtless waste more than their wages daily. This is especially true in small plants, and small plants preponderate in every city, and in these plants the possibility of great economics through the installation of mechanical stokers is small. Yet firemen can hardly be expected to know intuitively the chemistry of combustion, and certain it is that they have never been instructed in the fundamental principles of their occupation. Muscle and endurance have been considered the chief elements in the make-up of a fireman, and the arduous duties, too often performed in the dark, hot and ill-ventilated basements, have not attracted many men of intelligence.

The committee suggests that we might follow the example of the Prussian Government, which makes an annual appropriation for the purpose of giving instruction to firemen. Both academic instruction and practical demonstration is included in the course. In connection with Prussian government buildings and works, where stationary boilers are in use, it is required that: "As far as is in any way feasible, care should be taken that only such persons as have satisfactorily managed furnaces for a considerable time, shall be employed as independent firemen. If these persons have not gone through a satisfactory course at a fireman's school, opportunity should be given them as far as possible to attend one." Only when all methods of careful management and supervision of firemen and selection of fuel have failed to abate smoke, do the authorities recommend trying special appliances of a mechanical sort.

In St. Louis the Smoke Abatement Department causes to be posted in every boiler-room a list of "Directions for Firing." These are intended, primarily, for the users of low pressure steam heating plants. In such plants, especially, and in all other hand-firing boilers, efficiency is improved and smoke may be greatly lessened by close adherence to the following rules:

- 1—Fire frequently in small quantities and at regular intervals.
- 2—Break up lumps to fist size.
- 3—Carry a level surface over entire grate.
- 4—Avoid thin and bare spots on grate.
- 5—Keep the fires clean.
- 6—Fire one door at a time, and wait until that

fire is in good shape before charging the other door.

7—Leave furnace door slightly ajar for one minute after each firing.

These rules are good, if firemen will follow them, but the committee holds that a more certain solution of the problem in apartment houses and small buildings, where the demand for steam is too light to require the hot fire which is essential to perfect combustion and smokelessness, is the use of anthracite or smokeless coal or coke, or better still, to make use of central heating plants of sufficient capacity to ensure proper attention to economical methods of combustion and coal handling.

Prof. Goss, referring to the method of treating the small plant smoke nuisance, writes as follows: "The wisest and most effective course to follow with reference to such fires is to provide a satisfactory substitute and then abolish them. So far as such plants are now employed in the production of power, they can be rendered unnecessary through the cheaper and more effective distribution of electrical power. So far as steam from such boilers may at present be used for heating, they can be rendered of no effect through the supply of heat from a central station."

It seems to the committee that a combination of good hand firing and mechanical stoking will give real success, i. e., train men to operate scientifically the score or more of excellent mechanical devices now on the market. The committee believes the methods adopted by the Hamburg Smoke Abatement Society are so sound in principle, as to warrant publishing a description of their aims and work, by Mr. J. B. C. Kershaw, of London.

"The Hamburg Verein für Feuerungs-Betrieb und Rauchbekämpfung is, however, an entirely voluntary organization of steam-users, and its members are only bound by the common desire to obtain greater efficiency and less smoke from their steam-raising plants. The society has now (in 1906) been in existence three and a quarter years, and the following account of its organization, aims and work, is drawn from an explanatory pamphlet and from the two annual reports which have been issued since its inauguration in October, 1902.

"The work of the society is controlled by a committee of six to nine members, elected annually. The technical and scientific work is undertaken by the staff of experts retained by the society for this special work. At the date of the last report this staff consisted of a chief engineer, two assistant engineers, two instructors for firemen, and one clerk, while for special steam-raising and other trials, three additional assistants had also been employed. The chief engineer attends the committee meetings and takes part in the discussions relating to the work of the society. The funds of the society are drawn from three sources: From the annual subscription of its members; from payment for special work and reports for its members; from payments for outside work.

"The society is thus entirely self-supporting, and its success is dependent upon the value of the return it makes to its members for their contributions and fees. It is, therefore, gratifying to note that the membership shows steady growth. Starting with a few members in October, 1902, the register contained 60 firms and 249 boilers at the end of September, 1905, and fifteen months later these had increased to 115 firms and 351 boilers. The report for the year 1905 is not yet published, but I am informed by the chief engineer, that the membership is now 150, with 420 boilers under their control.

"The objects of the society, as set forth in the rules, are the attainment of the highest possible efficiency from the heating and boiler plants of its members, with the least possible emission of

smoke. To this end regular examination of these plants and of the methods of working them is undertaken by the expert staff of the society, and suggestions are made for improvements when such are required. The education and control of the firemen in the proper performance of their duties are also undertaken by the fireman-instructors on the staff of the society. Comparative tests of fuel, and tests of smoke-prevention and other appliances of a similar character, are also carried out by the expert staff, and the results are circulated amongst members of the society.

"Members of the society can demand that their boiler or heating-plant shall be regularly inspected, and that its working shall be tested and reported on at least three times a year. They have also the right to consult the chief engineer of the society regarding improvements and alterations in the design and working of their plant.

"They on their side are bound to allow the chief engineers and other members of his staff free access to their heating and boiler-plants at all times, and are bound to make the necessary provisions for conducting the tests. They are also required to carry out the suggestions made for improving the efficiency of the plant, especially as regards the abatement of smoke, and to submit to the chief engineer all plans for extension of the plant, or for change in the methods of work.

"Each boiler or heating-plant, when brought under the control of the expert staff of the society, is tested at the earliest possible date, and a written report upon the results of the examination is submitted to the owner. Should the firing have proved inefficient, one of the firemen instructors is sent to the works to give practical instruction to the firemen employed there, and tests of the plant are made at intervals until this fault is remedied. Defects in design are similarly dealt with.

"The annual subscription to the society for members without any boiler or heating-plant is 20 marks (\$5.00). Members having boilers or furnaces which they desire to place under the control of the experts of the society, pay a further 20 marks annually for each boiler or furnace.

"The extra charges for tests and reports are based upon the time spent upon them and the number of experts employed. Engineers are charged for at the rate of 20 marks per day, and firemen-instructors at 5 marks per day. Special reports upon patented appliances are charged for at the customary rates; members receive a special discount of 30 per cent. on these, as compared with outsiders."

Steam Jets.—There are many forms of application of the steam jet to boilers. Sometimes the steam is applied below and sometimes above the grate. Below the grate the effect is perhaps slightly to increase the draft, but mainly to soften the clinkers. Above the grate the steam jet is essentially for the purpose of inducing a draft of air over the fire and to mix the air with the gases from the coal. The steam itself is not a source of any heat.

Many devices for smoke prevention which are based on the use of the steam jet are of little value, the committee says, and seem to be made only to sell. Others are carefully worked out in their details and are really of use, especially when properly applied to meet the special conditions, and when combined with a device for automatically adjusting the supply of air to the volume of gases produced. Based on the fact that the volume of gases is great immediately after fresh coal is charged and slowly falls off until the next firing, these devices open a damper above the fire immediately after the closing of the fire-door, and by a dash-pot arrangement this damper is slowly closed, thereby regulating the

supply of air between the maximum and minimum amount needed.

A number of such devices are in successful use, and when properly applied and operated will prevent smoke. The cost of their installation is low compared with stokers, but they effect economy in coal consumption only to the extent to which they more perfectly burn the gases by the admission of neither too little nor too much air to meet the varying requirements of the fire.

Down-draft Furnace.—The principle utilized in the operation of this furnace, according to the committee, is not unlike that of the under-feed stokers, inasmuch as the volatile hydrocarbons pass through the green fuel before reaching the combustion zone. The result is that the volatile gases are intimately mixed with the supply of air as they are distilled off and the conditions are favorable for complete combustion when these gases attain the ignition temperature.

The down-draft furnace, according to the committee, is effective in reduction of smoke when properly handled, and it is not difficult to secure very satisfactory results so far as smoke prevention is concerned. It has the advantage over mechanical stokers in small plants, since the relative economy of the down-draft furnace is substantially as high with a single boiler as with a large plant. The very complete combustion is favorable to good economy of fuel and the possibility of high temperature of the products of combustion may result in a very considerable increase in the effective capacity of the boiler. The down-draft furnace is usually hand-fired, though large plants are frequently fed by a so-called automatic gravity system.

This furnace is considered well adapted to single boilers or to plants too small to warrant the installation of automatic stokers. It may be expected to effectively reduce the smoke emitted from the stack under reasonably favorable conditions, and to do it economically. The down-draft furnace requires a good draft for the best results and is not so well adapted as certain forms of automatic stokers to plants which must be forced at times greatly in excess of normal capacity.

Mechanical Stokers.—The large number of mechanical stokers which have been developed may perhaps be conveniently divided into four types. First, the forwardly inclined grate, of which the Roney stoker is an example. Second, the V-shaped grate, of which the Murphy stoker is a representative. Third, the under-feed stoker. Fourth, the chain grate. There are a number of successful applications of the principles represented by all of these types, and there are records of very successful performances of installations of many variations of each type. While each has special features of excellence, yet some installations and conditions are better suited to one type and some to another, according to the committee, and it is of the greatest importance that in the selection of a stoker the owner should make sure that he has the type best suited to his conditions, and that the details of the particular apparatus are developed on sound mechanical lines and based on mature experience.

While it can hardly be called a mechanical stoker, the application of pulverized fuel, which has been made familiar by its extended use in cement burning, for example, has had some success in firing boilers. It can hardly be said, however, that this method has passed the experimental stage. It is claimed that combustion can always be maintained with entire absence of smoke and with great economy, in that only about the theoretical amount of air is required, and the coal is very thoroughly burned, the remaining ash being a fine, clean powder. The very high temperatures are attended with some practical difficulties, which perhaps may be overcome with more experience.

From the point of view of smoke prevention the automatic stoker is merely a means for feeding the coal uniformly into the fire, and therefore uniform production of hydrocarbon gases. Uniform conditions make it much easier to maintain perfect combustion of the hydrocarbons, and hence to prevent smoke, but very many installations of automatic stokers smoke very badly,

Southern Pacific Improvements.

Pending the final reports of the engineers who are at work upon plans for the electrification of its lines across the Sierras, the Southern Pacific Co. is carrying out improvements which will immediately have the effect of greatly bettering traffic conditions between Sacramento and Truckee.

is shown in the fact that beginning last month the possible capacity of trains across the mountains has been increased from 30 to 45 cars, and the likelihood of another congestion of transcontinental freight, such as this year witnessed, would seem to be avoided.

The Southern Pacific line to Ogden is a single track, and traffic is carried on in both directions at once by the use of sidings or passing tracks. Between Roseville and Truckee there are 24 of these passing tracks, and the average length of each has been 1,950 feet. Half of the 24 are in the 46 miles of snow-sheds, which inclose the road between Blue Canyon and Truckee. The large consolidation locomotives have pulled freight trains whose greatest possible capacity, limited by the length of the sidings, was about 30 box and flat cars. To each of these sidings is being added some 700 ft. of new track, and with the 24 sidings, each 2,600 ft. long, it will be possible to dispatch freight trains hauled by three engines, of 45 cars each. With 45 cars moving in the same time that has been required to move two-thirds that number, it is patent how the saving in train movements will facilitate the handling of traffic.

What a great undertaking was the lengthening of these sidings is apparent when it is remembered that all of them are on a mountain division, where for the most part the roadbed is a shelf blasted out of the solid rock, and that half of the sidings lie in the snow sheds where every foot of extension means the reconstruction and widening of a corresponding length of shed.

The work, which is under the general supervision of District Engineer R. M. Drake, is being carried out by Assistant Resident Engineer E. C. Morrison. It began about the middle of July. The graders and track layers comprised 400 Greeks, 160 Hindus, and 50 Italians in addition to 50 or 60 native workmen. Three and a half



Construction Train on the Cascades Bridge in California.

often quite as badly as furnaces with poor hand-firing.

In order to prevent smoke, it is quite as necessary to maintain the proper conditions for good combustion with stokers as without them. To insure these conditions, it is customary to build a fire-brick arch over the stoker, either in the shape of a Dutch oven in front of the boiler setting, which is usually the better plan where room permits, or the arch is thrown across the fire-box between the fire and the boiler. It is usually quite difficult to maintain an arch in this position, owing to the high temperature to which the brick work is subjected on both sides, and many devices have been put forward to maintain these arches. One type, which appears so far to be quite successful, consists of special shaped bricks, which are perforated, so that air from the outside is permitted to travel the whole length of the arch within the chambers or flues formed by these perforations, and is delivered, considerably heated, at the rear end of the arch, where it supplies the air for the final combustion of the gases. The heat absorbed by this air keeps the bricks sufficiently cool to prevent their destruction. The Dutch oven construction has the advantage that this arch is free to radiate its heat through the top, and it is, therefore, relatively easy to maintain.

SMOKESTACK CINDERS from locomotives are being used for making producer gas at two places in Germany by the railway administration. The plant at Koenigsberg has three generators and three double-acting gas engines, each of 180 h. p. capacity. The engines are direct connected to electric generators. The other plant has two gas generators and two single-acting gas engines, each of 90 h. p. Both plants are said to be giving satisfaction, the consumption of cinders being reported from 1.3 to 2.4 lbs. per horse power, varying with the load.



The Turntable at Roseville, Cal.

By these improvements the company has theoretically increased by 50 per cent. the efficiency of its freight service across the mountains by additional sidings, while the great freight terminal at Roseville, on which work is now well under way, will further facilitate the handling of transcontinental traffic.

The immediate effect of these track extensions

miles of steel track was laid, and it was necessary to build 6,000 ft. of double snowshed at a cost of \$16 a foot. Seven gangs of 20 carpenters each were employed on this new work and in making repairs in the sheds. Seven million feet of lumber, which came from mills along the line, was used.

Between Smart and Tunnel 13 the excavation

was in loose rock, which was removed without great difficulty, except at Crystal Lake, where the work was in granite, which yielded only to Burleigh drills and a great deal of Giant powder. At Summit, which is, as its name denotes, at the top of the mountains, an entirely new track 3,100 ft. in length has been put in to handle the traffic which always congests at such a point. Here, too, the 65-ft. steel turntable was taken out and replaced by an 80-ft. table, to accommodate the largest engines.

In addition to the sidings, a double track is being laid between Truckee and Winsted, a distance of 2.7 miles. A year ago work was begun on a double track between Elvas and Loomis, 21 miles apart. This is complete, except for the 6 miles between Roseville and Loomis.

The heaviest grade in the Sierras is 2.2 per cent. at a point between Summit and Truckee on the eastern slope. Between Blue Canyon and a point 6 miles west of Truckee there are 13 tunnels. Tunnel No. 6, at Summit, is 1,800 ft. in length.

There are five regular eastbound passenger trains each day and the same number of westbound passengers and often these run in two or three sections. Besides many extra passenger trains there are ten freight trains each way daily. On a road as busy as this the importance of the lengthening of the frequent sidings, or passing tracks, which all but equal a double track line, can hardly be over-estimated.

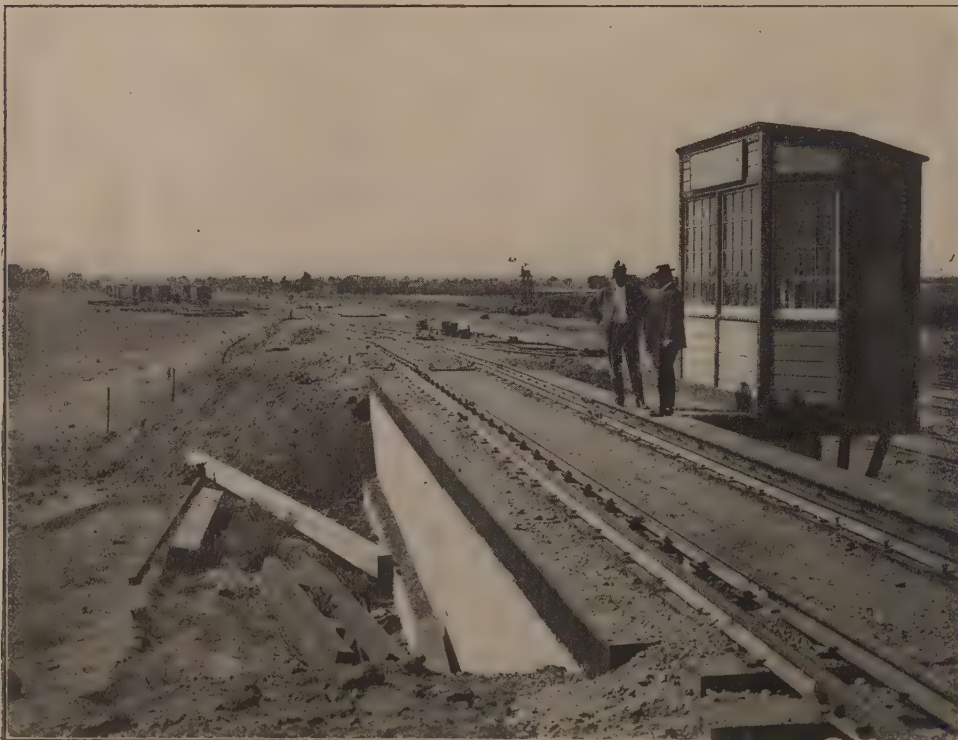
The great terminal being constructed at Roseville will affect the traffic of practically all the Pacific Coast. It will have a bearing upon the transcontinental traffic that goes across the Sierras to Ogden and the traffic that parallels the Pacific Ocean from Los Angeles to Portland. Roseville is the natural distributing point for

In the Roseville yard, which is 4 miles in length, the last of 50 miles of trackage is being laid. The receiving, departure and classification tracks, where the greatest volume of work will be done, comprise 27 miles. There are 3 miles of repair

completed are the car repair shop, two sand-houses, freight house, icing plant to accommodate 20 cars at a time, a commodious two-story clubhouse, two office buildings, an emergency hospital where a staff of nurses will be maintained,



Water Tank on Southern Pacific Line at Roseville, Cal.



The Hump in the Yards at Roseville, Cal.

freight in transit, for two reasons. The grades between that place and Sacramento are slight and the track straight, while from Roseville eastward the grades are heavy with many curves; consequently long trains can be brought to Roseville economically and broken up into smaller trains. In the second place, Roseville is the junction between the Ogden and the Shasta routes, and freight trains containing cars destined in both directions can be run here to be broken up.

tracks and the remainder are storage and warehouse tracks and industry spurs.

The first of two roundhouses, which are to be identical, is completed. This roundhouse contains 32 stalls, divided into four compartments separated by brick firewalls and automatic fire doors.

The machine shop, where repairs will be made, is ready for its equipment. Engineers' quarters adjoin the roundhouses. Buildings yet to be

and a lumber shed. Large rest corrals for cattle in transit will be provided. The machine shops and the two large turntables will be operated by electricity.

There are two main receiving and departure yards, an eastbound and a westbound, each 3,000 ft. in length. Into these trains will run as they arrive. The road engine will then uncouple and go to the roundhouse and a switch engine will push the train up the gravity hump. On the hump each car as it rolls along is weighed automatically and the weight recorded. One by one the cars are uncoupled and run down by gravity into the classification yards, the switchmen being provided with switching lists. When a classification track is filled with cars bound for a certain destination a switch engine pushes the train around the hump, instead of over it, to a departure track, a road engine is brought out and the train dispatched. When these yards are in operation a great deal of eastbound freight will be brought by way of Stockton and will not go into Sacramento at all.

At the west end of the yards a subway will be built under the tracks so that vehicles and pedestrians may cross without danger from the many trains. A 350,000-gal. steel water tank, fed from a reservoir in the foothills above Rocklin, will supply the yards with water through 3 miles of 8-in. pipe. Oil will be supplied from a 55,000-bbl. tank and a 65,000-gal. auxiliary tank and will be conducted through steam-heated pipes. In addition to the water column near the handsome new depot, there will be six water columns and as many oil columns conveniently located about the yards. Locomotives will be able to take oil and water at the same time.

The work at Roseville, which is under the direction of Assistant Engineer Norman Collyer, was begun in June, 1906, and will be completed next summer.

Mechanical Plant of the Brooklyn Institute Building.—I.

The Brooklyn Institute of Arts and Sciences has recently completed large extensions of its buildings at Eastern Parkway and Washington Avenue, near Prospect Park, Brooklyn, in the course of enlarging its museums and broadening its educational scheme. The entire northerly facade, over 500 ft. in length, has been completed of a structure that was laid out a number of years ago on a magnificent plan, to be erected in sections as the development of the work requires, and to embrace eventually a building over 570 ft. square with four open interior courts. A third section of the structure has recently been completed, the addition of which to the two earlier sections of the building has necessitated an entire revision of the power and mechanical equipments in order to accommodate the extended and enlarged services of the building and has resulted in the installation of a new power plant in a separate building which will amply accommodate

plan of a large hollow square about 575 ft. square, with interconnecting interior wings that will form four open interior courts, about 150 ft. square. In one of these courts the power plant was located, that at the rear of the present westerly wing being selected as most convenient for piping and power connections to the older sections of the building. In this court, space is available for extension of the plant to double its present capacity without interfering with the main building or any of the extensions contemplated. The portion of the structure at present completed was erected in three sections, of which the wing to the west of the central portion, 48 ft. wide x 175 ft. long, was the first to be constructed, about 9 years ago, the central or entrance division, 114 x 124 ft. in size next, being completed in 1902, while the easterly wing, similar in size to the original west wing, is the portion just recently completed. The two side wings are three stories and basement in height with the exception of the new easterly wing which, owing to a depression of the grade at that point, has a sub-basement and cellar in addition, while the cen-

tral portion has a large auditorium with gallery in the basement above which are two floors devoted to corridor purposes, and on the third floor level a magnificent sculpture hall connecting with the art galleries and rising to a dome surmounting this portion of the building. The west wing of the building is, with the exception of the third floor, devoted to museum purposes, with lecture rooms in the basement, while the new easterly wing provides laboratories, work and study rooms and upon the third floor an extension of the art gallery of the west wing. The building is of massive wall bearing construction with an exterior of stone and is of as nearly fire-proof construction as possible.

The main building has large quantities of side window and skylight glass exposure and is situated on an eminence in one of the highest sections of Brooklyn, so that its exposure is particularly severe, rendering the provisions for heating of special importance. The heating is accomplished throughout the entire building by direct radiation, the ventilation provided being independent of heating in all cases. The system is operated throughout at low pressure, using exhaust steam from the power plant and from the steam-using machinery in the various sections of the building and all radiation, both direct and the tempering coils of the ventilating systems, are fitted with pump condensation returns and vapor lines operated on the Paul system. All radiation is also fitted for automatic temperature control, utilizing the Johnson system with thermostats in the rooms heated governing motor valves on the radiation supply connections. The heating surfaces were proportioned with considerable care in all parts of the building, owing to the large interiors to be heated and the excessive exposure, and the radiator locations chosen are also the result of careful study. The total amount of direct radiation installed in the building is approximately 17,500 sq. ft., which is exclusive of over 7,650 sq. ft. in the tempering coils of the ventilating system; of the direct radiation 5,200 sq. ft. is in the original west wing, about 5,300 in the central wing and 7,000 sq. ft. in the new east wing which, although of the same size in plan as the original west wing, has a considerably greater exposure due to the addition of a sub-basement floor above ground level, permitted by the depression in the grade at that portion of the grounds.

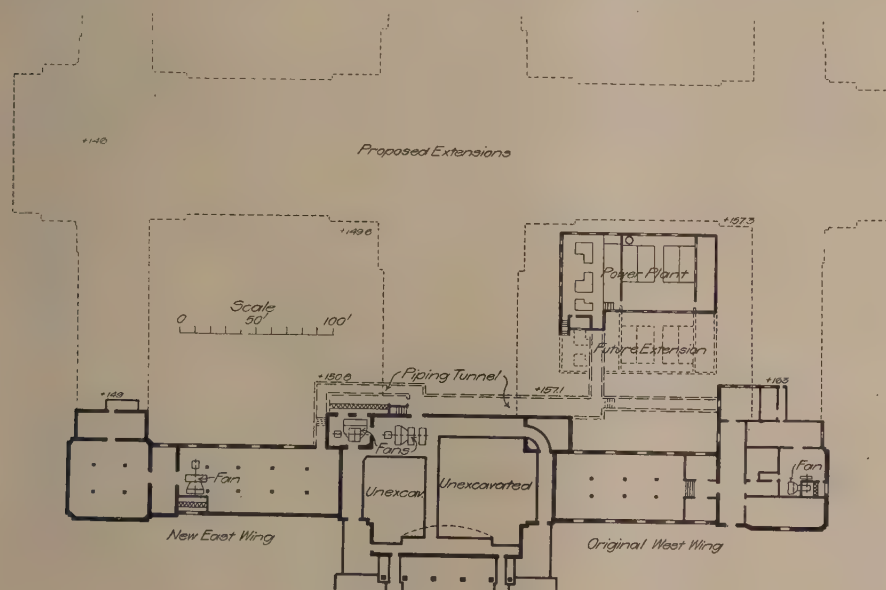
A feature of the heating installation is the concealment of practically all radiators in exhibition rooms and in all public portions of the building; in all the basement and sub-basement work rooms and laboratories and in auxiliary rooms the radiators installed are exposed. Also all piping is concealed, the rising lines from the basement or cellar being run in chases in the wall construction with connections to the radiators behind partitions or under the floor construction. The radiators are all installed in the usual locations under window-sills to counteract window glass exposure and for the concealed units, recesses or pockets have in all cases been provided under the sills for grilled enclosures to contain them. In the auditorium, the few radiators which are installed under the four rear windows, are located in special pockets having intake openings near the floor line and delivery registers in the sills. The radiator units are installed in varying heights in accordance to the height of window sill and where low sills are encountered they are in some instances installed of the 3-column type, necessitating a recess 15 in. deep. The recesses are all lined with galvanized iron and asbestos board and are faced with removable brass band screens. A convenient feature of the enclosing screens is the provision of small door openings, about 12 in. square, at the lower side on either end for access to the motor valves on the radiators of the temperature regulation system, which obviates the necessity of removing the screens in their entirety whenever access to the valves is necessary.

Large amounts of surface are provided in skylight coils to counteract the exposure of the large skylight areas, practically the entire third floor of the east and west wings being devoid of side window lighting, on account of a peculiar cornice construction of the exterior of the building, and thus fitted with skylighting for use as picture galleries and sculpture exhibition halls. These coils are of 1 1/4-in. iron pipe, surrounding the skylight and varying in surface for the different sizes of the skylights up to 720 sq. ft. of heating surface. In the roof of the central portion there are a number of small skylights surrounding the central dome, which are fitted with coils from 50 to 60 sq. ft. each. The coils are in all cases installed under the upper outside lights, being screened from the galleries by the lower ground glass lights, and under them are suspended drip pans of heavy galvanized iron construction with connections to sewer to dispose of any leakage of condensation that might occur.

the division now completed and is capable of expansion to provide for a considerable portion of the extensions of the main building projected. The mechanical services have from the beginning been operated by an isolated plant of the institute and includes heating, mechanical ventilation and electric supply for lighting and power purposes, and at present require a power plant of 700 boiler horse power capacity. An interesting feature of the present power lay-out is that while the new power plant was laid out on a carefully studied plan with permanent construction and provision for considerable future extension, it is of a temporary nature as it cannot be extended sufficiently on the present plan to provide adequately for all the extensions to the main building that are contemplated. As it will, however, be a number of years before the main structure shall have been extended to a point beyond the capacity of the present power plant, it has been arranged to proceed with the power scheme as at present laid out, which will provide for the extensions to the main building until fully one-half completed, whereupon the power requirements of the ultimate extension shall become defined and a suitable location for the necessary enlargement of plant be provided.

The institute building as now completed with the new detached power house is shown in ground plan, together with an outline of the extensions proposed, in an accompanying drawing. The building is, as above stated, laid out on the

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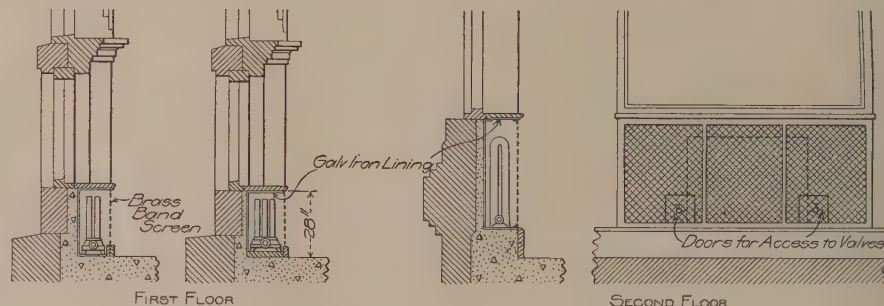


Plan of the Present Building of the Brooklyn Institute.

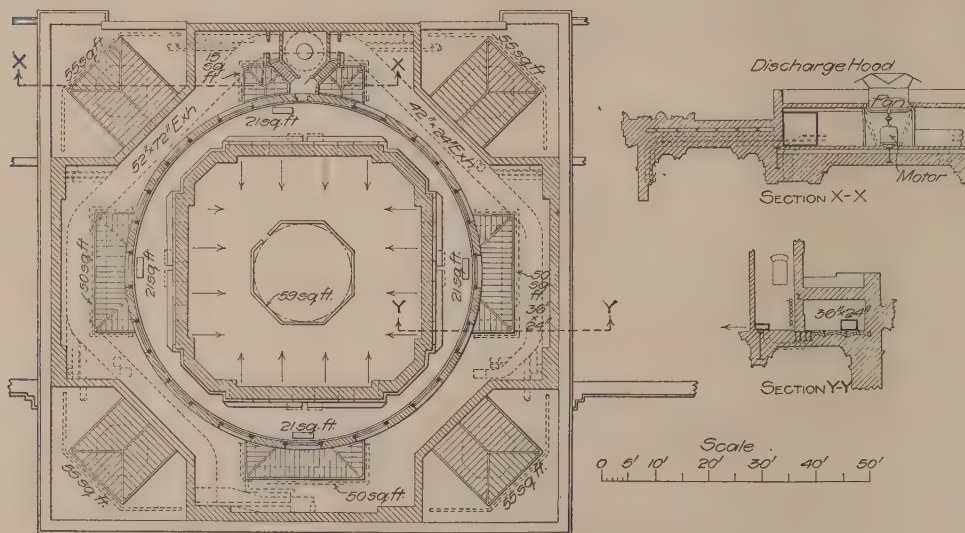
purpose. The risers connect in the basement or sub-basement into distributing mains, which, owing to the construction of the three different sections of the building at different times, are arranged in three different divisions. Those supplying the central portion and east wing originate in a low-pressure exhaust steam main from the power plant of the building, while that of the older west wing is an independent system supplied with exhaust steam from an engine driving the ventilating blower and from the steam pumps with make-up from the high pressure steam system when the exhaust is insufficient for proper heating. This latter main in the basement of the old west wing is an 8-in. line into which connects a 5-in. exhaust main from the original steam-using equipment in this portion and a 6-in. live steam make-up connection through a reducing valve, and which is carried around on the basement ceiling making connections with the riser lines and the tempering coil of the fresh air supply fan for that division of the building. The central portion of the building is supplied by a 10-in. and the east wing by an 8-in. low-pressure heating main, which in either case encircles its basement, reducing in size as connections are made to the risers. In addition to the riser lines, steam is supplied to the tempering coils of a ventilating blower in the east wing and to those of two blowers in the central portion. The 8-in. and 10-in. basement mains connect with a 12-in. low-pressure heating main that originates in the exhaust steam system of the power plant some distance away, the supply main being run from

tion gathering mains in the basement or sub-basement that lead in each section of the building to a pair of return pumps. These pumps are 6x4x6-in. Deane duplex steam pumps operated under control of Kieley pump governors, receiving steam from high pressure lines carried over from the main power plant and exhausting through grease extractors into the local divisions of the low-pressure heating main. There are two of these pumps in both east and west wings so that the fan system tempering coils and the direct radiation may be operated separately if desired, while in the central portion of the building there are three such pumps, there being two fan systems with tempering coils here in addition to the direct radiation, and the connections to each group are so interconnected and by-passed, that either unit is interchangeable upon any of the services. The pumps of the central portion

sion entirely without interference to the power services. The court at the rear of the westerly wing of the structure was selected as the more convenient location for connection to present piping systems of the older sections of the building, in which projected court space, an available free area of about 150 ft. square was afforded. The plant was laid out for capacity of 700 boiler h.p., with building and equipment arranged for approximately doubling this initial capacity by extension to the front toward the present west wing, by means of which a duplicate equipment of that now in place may easily be installed, which will provide plant capacity sufficient for fully one-half of the extension of the museum building as projected. When it shall become desirable to increase the building beyond this extent in future years, it is the plan to provide a new power plant of the increased size neces-



Typical Radiator Enclosures underneath Window Sills.



Arrangement of Radiation underneath Special Skylight at Base of Dome.

the power plant to the basement of the building through a piping and wiring tunnel underground at the rear. This heating main has in the power plant a live steam supplementary connection consisting of a 6x12-in. Kieley pressure reducing valve for adding live steam to the system when the exhaust supply is insufficient. The system in the west wing having no low-pressure connection from the main power plant, is supplied with high pressure for this equipment through a 7-in. main which is extended to the basement of this portion through another division of the piping tunnel connecting the power plant with the main building.

Condensation is returned from all radiation by direct pump returns, return pumps being installed in each of the three sections of the building heated, which deliver direct to a return tank in the power plant, air and vapor being removed from the radiation separately through connections to a Paul system. Return risers parallel all of the steam supply risers to the upper floors which are of unusually large sizes ranging from 1½ to 2½-in. pipe, and connect into condensa-

tion gathering mains in the basement or sub-basement that lead in each section of the building to a pair of return pumps. These pumps are 6x4x6-in. Deane duplex steam pumps operated under control of Kieley pump governors, receiving steam from high pressure lines carried over from the main power plant and exhausting through grease extractors into the local divisions of the low-pressure heating main. There are two of these pumps in both east and west wings so that the fan system tempering coils and the direct radiation may be operated separately if desired, while in the central portion of the building there are three such pumps, there being two fan systems with tempering coils here in addition to the direct radiation, and the connections to each group are so interconnected and by-passed, that either unit is interchangeable upon any of the services. The pumps of the central portion

Power Plant:—The new temporary power house was, as above stated, located in what will be one of the open interior courts of the building, as extended, so that further building construction may be carried on in the process of exten-

sary, in some other portion of the building or make such other provisions for the mechanical services of the building as may then become desirable, the present plant in the interior court space to be subsequently removed.

As the plant is destined to remain in service a number of years, before being supplanted by one of greater magnitude, the power house was designed of comparatively substantial construction of brick with concrete floors and roof, and is of ample size for convenient arrangement of apparatus. The exterior of the building is severely plain and for minimizing the interference with the lighting of the west wing of the museum from the rear, it is depressed, with its floor level from 6 to 12 ft. below grade, the roof of this structure rising, in fact, but about 10 ft. above grade. The structure as at present built is 88 ft. in length by 53 ft. wide, with a 14 x 24-ft. extension at one end over the piping tunnel that connects with the museum building. The extension proposed for doubling the capacity of the plant will increase the width to about 90 ft., so that the structure will be practically square, as indicated in the museum ground plan. The power house is divided into a 38-ft. engine and pump room and a 46-ft. boiler room, the engine room having a 13-ft. clear headroom, with floor depressed 6 ft. below grade, while the boiler room floor is depressed 5 ft. below this level, giving a clear headroom of 18 ft. A section of the engine room, 14 ft. in width, adjacent to the division wall, is depressed to the boiler room floor level to accommodate the extensive equipment of pumping units, filters, feed water heaters, etc. In the wing extension off the engine room there is an 8 x 13-ft. office for the chief engineer, with floor on level of the exterior grade, and in the opposite end of the engine room, over the pump floor, a 5 x 13-ft. toilet room. Ample lighting is afforded throughout by windows above grade near the roof line on all sides.

The question of fuel handling was simplified by the depression of the boiler room floor below grade, as an underground bunker communicating with the boiler room was thus made possible, onto the top of which coal wagons may be driven directly for dumping through coal holes in the

roof. Such a bunker, 14 x 50 ft. inside measurement, was constructed at the westerly end of the boiler room, with a reinforced concrete roof on level with grade at that point and containing four coal holes, through which fuel may be dumped. The bunker has a clear inside height of 11 ft., and about 30 ft. of it is used for coal, so that when filled to the roof it has a capacity for about 150 tons of coal. The coal is wheeled to the firing floor in barrows. Ashes are removed to the surface in barrows on a hydraulic elevator at the rear of the boiler room for hauling away in ash carts.

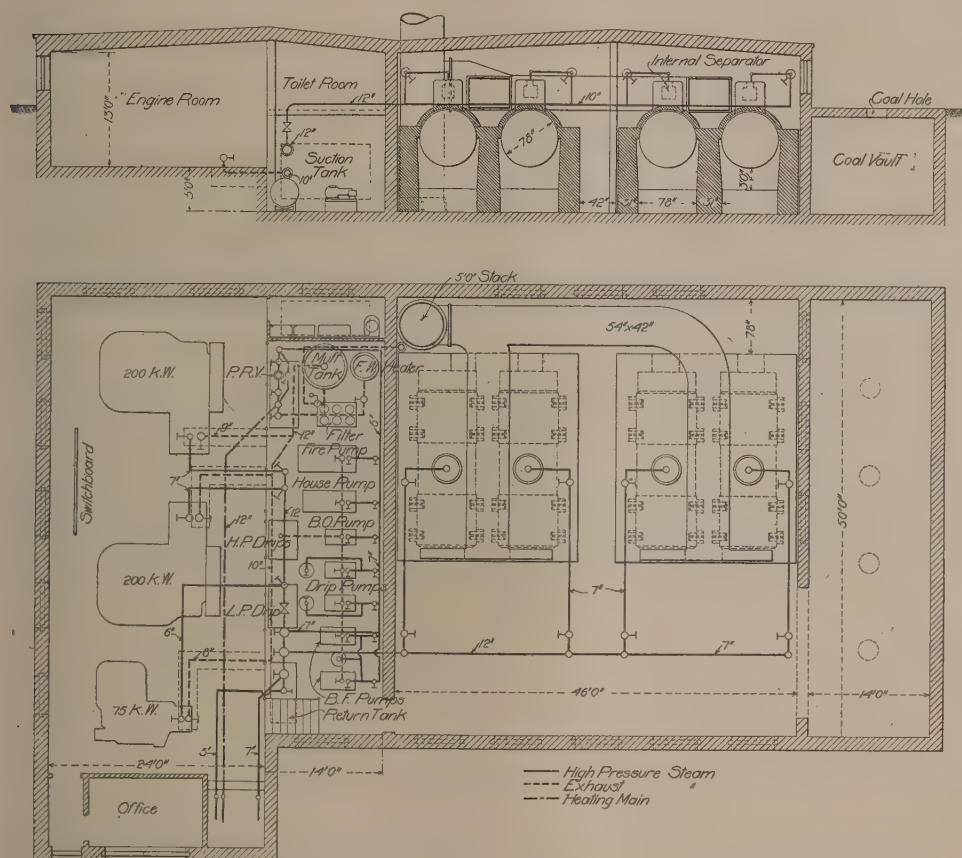
The boiler equipment consists of four 6½ x 18-ft. horizontal return tubular boilers, built by the Coatesville Boiler Works, which are conveniently arranged in two settings, with a 4½-ft. space between them, a 6½-ft. space at the rear and facing a 20-ft. firing floor. Each unit has 120 lap-welded tubes 3½ in. in diameter, giving a total

which draw from the condensation return tank or from the city water mains and deliver through a 3-in. boiler feed main over the boilers. The latter has a 2-in. branch to each boiler, which connects into a Fox water arch for preheating and has a check and two stop valves. The delivery from the pumps is connected to pass the feed first to a Ward feed water filter and then to a Berryman feed heater, which is inductively connected to the exhaust steam main of the plant. The delivery from two Nathan monitor injectors, which have been installed to supplement the feed pumps, is also connected to pass through the filter and heater, either of which may, however, be by-passed if desired. The Ward filter is of the usual cast-iron chamber type, having six cylinders, 12 in. in diameter by 7 ft. in height, which are fitted with cast-zinc bars and animal charcoal. The Berryman heater is a 39-in. by 13-ft. heater, containing 215 sq. ft.

the 8-in. distributing header in the engine room, from which a 5-in. and two 7-in. branches are taken off to supply electrical generating units, a 7-in. line to supply a pump and auxiliary machinery header, and a 3-in. and a 7-in. branch to the museum building to supply steam using apparatus there located. The auxiliary header supplies the equipment of seven steam pumps and, in addition, has a 6-in. connection to the reducing valve, through which live steam is supplied to the low-pressure exhaust heating system for use when the exhaust supply is insufficient for adequate heating. The high-pressure lines in both the power plant and in the tunnel ways to the museum building are well drained through Nason traps, each drip point, as well as also the steam separators at the steam using units, being dripped separately through a trap with by-pass. These traps all deliver into a return line that connects with a 3 x 5-ft. drip tank, from which the condensation is returned to the boilers by a 6 x 4 x 6-in. Worthington duplex pump under control of a Kieley pump governor. The piping used is standard full-weight wrought-iron pipe, with extra heavy flange fittings and corrugated copper gaskets and fitted with extra heavy pattern gate valves having bronze discs and seats. All piping, both high and low pressure, is insulated with magnesia pipe covering, canvas jacketed, while the domes of the boilers, the feed water heater, filter and all tanks, separators, etc., are covered with magnesia blocks 1½ in. thick, protected with canvas jacketing. The smoke connections and also the stack up to the roof are covered with similar 1½-in. magnesia block, on wire netting over a 2-in. air space, finished with hard plaster and painted with black japan varnish.

The exhaust steam system which serves as the basis of the low-pressure heating supply, consists of a 12-in. header in the pump pit directly underneath the high pressure header which has a 6-in and two 9-in. connections from the generator engine and a 5-in. connection from an auxiliary line from the pumps. This header leads directly to a muffler tank at the southerly end of the pump pit and to an inductive connection to the feed water heater, with near the latter, a connection to a 10-in. back-pressure valve that delivers through a 10-in. riser to an exhaust head near the top of a smoke stack for atmospheric relief in case of excessive pressure on the exhaust system. The muffler tank is a Potter muffler and oil separator, 4 ft. in diameter by 6 ft. high, containing 24 galvanized wire discs and from this a 12-in. connection is extended to the Museum building for the low pressure heating supply. Near the muffler tank the live steam supplementary steam supply connection, above referred to, is made, there being in addition a by-pass around the reducing valve permitting of manual control if desired. Drainage from the exhaust system is effected by a low-pressure drip system, having connection to the cylinders of all engines and pumps, to the exhaust heads, the muffler tank and the feed heater, and delivering into a 3x5-ft. cylindrical drip tank. The low-pressure drip is like that from the high-pressure system, removed by a 6x4x6-in. Deane duplex pump under control of a Kieley pump governor, but being contaminated with lubricating oil, is wasted to the sewer. The drip connections from the engine and pump cylinders to this line are made separately through steam traps.

The electrical current supply for power and lighting purposes is generated by three direct connected units, two of 200-kw. capacity and one of 75-kw., which are conveniently and accessibly arranged with the smaller unit near the center of the projected building as shown in the ground plan. The engines are all simple high-speed machines built by the Harrisburg Foundry & Machine Works of Harrisburg, Pa., the larger



Present Power Plant of the Brooklyn Institute.

heating surface of approximately 2,300 sq. ft., and has a 36-in. dome over the center sheet, in which is fitted a Potter mesh separator and superheater. Each boiler is set in a substantial brick setting, with flush cast-iron fronts, each shell being supported by eight lugs with roller bearings and each has grates $6\frac{1}{2}$ ft. square, with fire brick bridge walls rising to within 14 in. of the bottom of the shell. The smoke connections consist of a 42 x 54-in. breeching over the middle of each double setting, connecting at the front with the smoke boxes of either boiler and at the rear into a cross breeching leading to the stack in the rear corner of the room. This stack is a 60-in. unlined stack of $\frac{3}{8}$ -in. wrought iron plate and rises to a height of 125 ft. above the grade. Each flue connection has a hand-operated tight-closing damper, while in the main breeching connection to the stack there is a main damper operated by a Spencer automatic damper regulator for control of the draft by the steam pressure.

The boiler feed system consists of an equipment of two 7½ x 5 x 6-in. Deane duplex pumps,

of surface made up of 2 in. seamless brass tubing. Each of the boiler shells has a 3-in. protected blow-off connection from the lower rear end, which leads out to the rear of the setting to a 3-in. blow-off main connecting with a 3 x 8-ft. cylindrical blow-off tank at the rear of the pump space in the engine room. This tank has a cooling coil, consisting of 60 lin. ft. of 3-in. brass pipes, for partially cooling the hot blow-off discharge, after which it is raised to the sewer by a 6 x 4 x 6-in. Deane blow-off pump. Vapor from this tank is removed by a 2½-in. connection to a 4-in. vapor riser that is carried up alongside of the smoke stack to a copper exhaust head.

The high-pressure steam piping of the plant is laid out with a simple boiler room header, delivering into a distributing header in the engine room, which is of extra heavy piping throughout and without duplication. The boiler branches are double valved 7-in. connections, which deliver into a 12-in. header arranged longitudinally over the center of the firing floor and below the level of the boiler branches to facilitate drainage. This line extends through the division wall to

unit having 22x20-in. cylinders and a rating when operating at 200 r.p.m., with an initial steam pressure of 80 lb., of 320 h. p., while the smaller unit has a 15x14-in. cylinder and a rating, at 275 r. p. m., of 120 h.p. The engines have 7 and 5-in. steam supply connections respectively, each with a DeRycke steam separator, and each engine is fitted with a Manzel oil pump for cylinder lubrication. The engines are direct connected to Keystone multipolar direct-current compound-wound generators built by the Burke Electric Co., of Erie, Pa. These generators are wound for 125 volts and are designed to deliver full load for 24 hr. per day without undue heating.

The generator circuits are controlled upon a 3-panel switchboard of Tennessee marble in the engine room which contains the necessary indicating instruments, circuit breakers, rheostats and switches for the regulation and control of the generators, but the distribution at this plant is arranged in a novel manner, current being delivered from the generator panels, direct to independent distribution switchboards in each of the three sections of the museum building, from which the local feeder circuits are independently controlled. This arrangement effected a considerable simplification of the switchboard equipment for the plant and places the control of the distribution at points where it is most effective locally.

In the west wing of the museum building, the first section to be built, connection is made to a distribution switchboard which served the early lighting plant installed originally in the basement of that section; here the lighting circuits of this wing and an electric elevator are controlled upon the distribution originally laid out. In the central wing, there are two switchboards, one for general lighting distribution and the other lighting control for a large auditorium in the basement, the latter having a complete equipment for theatrical effects, including four dimmers. In the new easterly wing there has also been installed a similar switchboard for local lighting distribution. Each of the wings has a separate feeder connection from the power plant switchboard for direct supply and there are inter-connecting circuits between the local distribution boards in reserve for emergency purposes.

The power plant equipment and heating system of the institution were designed by Mr. Alfred R. Wolff, New York. The contractor for the power plant equipment was the E. Rutzler Co., New York. The electrical equipment and distribution system was laid out by Mr. Freemont Wilson, New York. Messrs. McKim, Mead and White, New York, are the architects for the buildings of the Institute.

(To be continued.)

ELECTRIC HEATING is being tried in France for drying paper, in place of steam. Where the machine permits it is considered preferable to place the resistance, in which the heat is developed electrically, against the inside metal walls of the cylinders. A special advantage claimed for this system of heating is said to be the ease with which the temperature of the cylinder can be regulated while in operation. In the case of a machine producing 132 lbs. of paper per hour, which paper reaches the dryers with 50 per cent. of water to be evaporated, the electric heating must be capable of evaporating 66 lbs. of water per hour. In such a case, in order to avoid injuring the paper, progressive drying is recommended with three cylinders having a temperature of 158°, 212° and 250° Fahr., respectively. While such drying calls for a considerable amount of current, it is believed in the French plants where the experiments are being conducted that the cost is not excessive where current is furnished by hydro-electric plants belonging to the mills.

Coal Mining and Coke Making in the Trinidad, Colorado, District.

The chief known coal deposits of the Rocky Mountain region exist in a belt along the eastern base of the main range, extending southward from the Canadian boundary fully 1,000 miles, through Montana, Wyoming, Colorado and New Mexico. Although the coal-bearing formations are not continuous throughout this belt, which is of varying width in different sections, they have been found in about 60 per cent. of the distance. Another less extensive area of coal measures occurs along the western base of the Rocky Mountains in Wyoming, Utah, Colorado and New Mexico. Between the deposits on the eastern and those on the western slope are numerous isolated areas of coal measures, but in most of these the strata have been so much disturbed that coal-mining operations are carried on with difficulty. Coal from the various deposits has been mined extensively in southern and western Wyoming, in various parts of Colorado, in sections of Utah and in northern New Mexico for many years, but by far the greatest output has been maintained in Colorado. The principal fields of operation in that state are in the eastern and central part, near Denver, in the Walsenburg district, 175 miles to the south of Denver, in the Trinidad district at the extreme southern part of the state, and a few isolated sections along the western slope of the mountains. The coal fields of the Trinidad district were among the first in the state to be opened, and have been developed recently until the mining operations in that district are already the most extensive west of the Mississippi River, while new developments are being made continuously.

The portion of the Trinidad district that has been developed is approximately 20 miles wide, from the north to the south, and 45 miles wide, from the east to the west. The coal measures of this district are known to continue to the east from the present developments, but to the north they end in the measures of the Walsenburg district. The western boundary is quite well defined, however, by a practically continuous vertical strata of granite that extends almost exactly from north to south for several hundred miles close to the eastern base of the mountains. A range of mountains along the southern edge of the district interrupts the coal measures there, but extensive mining operations in coal of the same general characteristics are carried on in northern New Mexico, in the vicinity of Raton.

The workable coal measures in the Trinidad district are above an almost uniformly continuous stratum of bed rock, generally termed Trinidad sandstone, which lies at varying depths, depending on the topography of the country. Three principal series of coal veins, with an occasional occurrence of a fourth series, exist above this sandstone. First, is the Berwind series directly over the sandstone; then, about 60 ft. above that is the Hastings series and 30 ft. above the Hastings is a third rather indefinite series that is workable in a few localities. The fourth series, termed the Del Agua, is approximately 200 ft. above the third indefinite series, but thus far only a few mines are operated in it. The coal veins in all of these series frequently vary greatly in thickness and quality in short distances, so that mining operations are carried on with no small uncertainty. The veins that are worked range from 4 to 7 ft. in thickness, the average normal thickness being about 6 ft.

The average analysis of the coal produced in the district is about as follows: 60 per cent. of fixed carbon, 30 per cent. of volatile carbon and 10 per cent. of ash. First grade coke for blast furnaces and smelters can be produced readily from this coal, and as very little coking coal has been developed west of the Mississippi River, or,

in fact, west of Pennsylvania and West Virginia, a great demand for coke for various purposes exists in the mining regions readily reached by rail from this district. The character of the coal and the demand for coke has consequently resulted in the installation in the Trinidad district of a large number of coke-oven plants of large magnitude. As only the slack and the smaller sizes of the run-of-mine coal are generally used in this district in making coke, the coal output is correspondingly large, the coal being of excellent quality for steam and commercial purposes.

The principal operator in the Trinidad district is the Colorado Fuel & Iron Co., which owns a large number of properties in Colorado, Wyoming, Utah and New Mexico. The largest single property of this company is the extensive steel works at Pueblo. These works embrace 6 blast furnaces and have a normal output of about 42,000 tons of steel rails each month, besides various other products. An outline of the plant, equipment and methods of Colorado Fuel & Iron Co. in the Trinidad district will serve, therefore, to show the character and extent of the workings in the latter.

Most of the recent developments of this company in the Trinidad district are along the southern division of the Colorado & Wyoming R. R. This division extends up the canyon of the Las Animas River from a connection with the main line of the Atchison, Topeka & Santa Fe R. R. at Jansen, 2 miles from Trinidad, to Tercio, a distance of 31 miles, and was built to develop the coal lands of the region through which it passes. The construction and maintenance of this railroad are at least equal to those of any of the trunk-line roads in the same region. The difference in elevation between Jansen and Tercio is about 1,831 ft., but the maximum grade in the first twelve miles of the railroad is 1 per cent. and in the remainder of the distance the maximum is 2 per cent. These comparatively moderate grades in the rough country traversed were obtained by following quite closely the course of the river. Since the balance of traffic is very largely down-hill toward Jansen, the existing grades introduce few operating difficulties.

In the construction of the railroad the embankments were made 16 ft. wide on top and the roadway in excavation 18 ft. wide in rock and 20 ft. in earth. The track has 75 lb. and 80 lb. rails laid on native and Texas pine ties. Tie plates are used on all curves, so the soft wood ties are quite satisfactory. Nine miles of the track from Jansen to a station called Segundo are ballasted with crushed stone; the yards and much of the balance of the line are ballasted with waste from the washeries at the coking plants and with coke breeze. The curves above 4 degrees are spiraled, and maximum grades are compensated for curves.

The principal stream crossings are made on four single-span and two double-span steel bridges, carried by concrete abutments. The spans are each 105 ft. long, of the lattice truss type, and are designed according to Cooper's E 50 loading. The remaining stream crossings are small and are made on pile trestles or masonry culverts.

The principal yard on the line is at Segundo, where an eight-stall round house and a repair shop is maintained. This division of the Colorado & Wyoming R. R., together with other divisions, has three hundred 100,000-lb. capacity Ingolsby bottom-dump coal cars, which are used exclusively in the operations of the Colorado Fuel & Iron Co. Coal from the mines is hauled in these cars, while coke from the oven plants is hauled in regulation coke cars from various foreign lines.

The company operates five mines and two extensive coking plants on this division of the Colorado & Wyoming R. R. The first and large-

est of these mines is at Primero, on a three-mile branch that leaves the main railroad just above Segundo. This mine has produced from 2,500 to 3,000 tons of coal a day and was at one time one of the heaviest producers west of Pennsylvania. In a straight line Primero is only a mile from Segundo, but it is 300 ft. above the latter, so the branch of the railroad had to swing around the hills to avoid exceeding the maximum grade of 2 per cent. Like practically all of the mines in the Trinidad district, the one at Primero is worked from a number of drift entries and slopes; in fact, none of the mines in the district are worked from shafts. Six working entries, with the necessary ventilating openings, are used in taking out coal. Two of these openings are on one side and the remainder on the opposite side of the canyon up which the railroad is built. The mining operations are carried on by the room and pillar system from side entries. The physical character of the coal is such that it can be removed readily with picks and shovels with comparatively little blasting. For this rea-

to operate the haulage engine for the main entry and also to two 18 x 17-in. Ridgway engines, each belted to a 120-h.-p. Jeffrey generator. The water supply for the camp, in connection with the mine, is raised from the Las Animas River to a reservoir on a hill above the mine and camp by pumps at Segundo.

At Segundo two coal washers, each with a capacity of 1,200 to 1,500 tons a day, and 800 beehive coke ovens are in operation. The slack and fine coal from three separate mining operations, besides Primero, are delivered to these two washeries. One of these mines is an extensive new development on the main line of the Santa Fe R. R. at Morley, about 10 miles south of Trinidad, and the other two are on the Colorado & Wyoming R. R. adjacent to Segundo; one of these two is also a new mine at Frederick, a mile below Segundo, and the other is a smaller mine at Quinto, above Segundo. The slack and fine coal are delivered to Segundo from all four of these mines in the 100,000-lb. Ingolsby dump cars. The two washery buildings are located so

eries in 6-ton 4-wheel larry cars. These cars operate from the storage bins to the ovens on trestles and thence along the top of each pair of rows of the ovens on a track carried by I-beams, supported by masonry piers in the spaces between the ovens. The grade of the tracks on the trestles is such that the loaded cars go down to the ovens by gravity; the empty cars are pulled back up to storage bins by wire haulage cables, operated by steam-driven hoisting engines at the washeries. The larry cars, however, are being equipped to operate electrically, and trolley wires are being installed to deliver power to them.

As originally built all of the ovens in the various coking plants of the Colorado Fuel & Iron Co. were operated by hand. The pairs of rows of ovens were built with a wharf along each side of the row and with two standard-gauge railroad tracks between each two pairs of rows. Arrangements are now being made at Segundo and at several other coke-oven plants of the company to install electrically operated Covington machines for pulling coke from the ovens and loading it into cars. To this end the wharves are being lowered and a standard-gauge track laid on each of them at the new grade. The pulling-machine which serves one row of ovens will operate on the track close to that row and load coke into cars on the track across the space between the pairs of rows. The two tracks in each space will be connected by cross-overs at intervals, in order that the machines on the adjacent tracks may operate without interference. The only changes in the ovens thus required by the installation of the pulling machines is the widening of the oven doors from the old standard of 34 in. to 48 in. This change increases the capacity of the machines from 20 to 40 ovens in 24 hr. with 72-hr. coke, the corresponding capacities being even greater with the 48-hr. coke, which is produced in most of the coke-oven plants of this company.

A central station supplies power to operate the engines of the washeries and for the various other equipment at Segundo. The boiler room of this station contains ten 100-h.-p. return tubular boilers, which are equipped with fans for producing induced draft, so they may be fired with coke braze mixed with fine coal. The fuel is delivered to the boiler house in cars and is raised to overhead storage bins by bucket elevators. From these bins it flows to the firing floor by gravity and is fed by hand. The ashes are carried by a conveyor from the boilers to a storage bin over the track along the building. A 150-kw. 250-volt Thompson-Ryan generator, direct connected to a 240-h.-p. McEwen engine, has been installed to supply power to operate the larry cars and coke-pulling machines. Until all the power produced by this unit is required at Segundo for these purposes it will be transmitted to the mine at Frederick to operate the electric locomotives which are to be installed there to collect the mine cars and deliver them to the tippie at the railroad. As soon as more power is required at Segundo another generator similar to the one now in service will be installed.

The water supply for both Segundo and Primero is obtained from the Las Animas River. A pumping station on the bank of the river at the former contains two 500-gal. Jeansville compound duplex pumps, supplied with steam by two 100-h.-p. boilers. One of these pumps delivers against a head of 175 lb. to an 8-in. main extending to a 50 x 70 x 12-ft. reservoir at Primero, and the other delivers through an 8-in. main to a reservoir of the same size on the hill above Segundo. The discharges of the two pumps are cross-connected, so either pump may deliver to either reservoir. The water is piped from the reservoirs to all parts of the adjacent camps, so an ample supply for general use, do-



Washery, Coke Ovens and Railroad Yards at Segundo.

son no under-cutting or other mining machines are employed. The same condition likewise exists throughout the district, all mining being done by hand.

The main entry of Primero is over 6,500 ft. long and has a maximum grade of 4 per cent. The mine cars are collected to it from the side entries by electric locomotives and are hauled from the inner end to the mouth of this entry in strings of 10 to 12 by a wire-rope haulage cable, operated by an Ottumwa steam hoisting engine, with two 72-in. drums. The cars in the other three hauling entries, adjacent to the main entry, are collected and delivered to a point on the side of the canyon near the mouth of the main entry by electric locomotives. The two entries on the opposite side of the canyon are also served by electric locomotives.

A 3,000-ton double tippie, built across the canyon and over the railroad tracks, is arranged so cars from either side of the canyon may be delivered to either of the two tipples, which are of the Mitchell automatic-dumping type. The cars are hauled from the mouth of the entries to the tippie by three 25-ton locomotives. The coal is passed over grizzlies as it falls through the tipples into the railroad cars below, in order to remove the slack and fine coal. The coal retained by the grizzlies is shipped for general consumption, while the remainder is taken to Segundo in standard-gauge cars to be used in making coke.

Power for operating the main haulage cable and the electric locomotives is supplied from a central station. This station contains six 100-h.-p. return tubular boilers, which furnish steam

their transverse center lines are coincident, but they are spaced apart to provide room for two standard-gauge tracks between them. Two 400-ton storage hoppers are placed under these tracks, adjacent to one end of the washeries, to receive the slack and coal from the various mines. A large coal crusher is also installed at one side of the tracks near the end of the hoppers, in order that run-of-mine coal may be reduced before being introduced to the washeries.

A flight conveyor in each of the track hoppers delivers to a bucket elevator extending to a bin in the top of one of the washeries. The arrangement of the both latter and, in fact, of all the washeries operated by the Colorado Fuel & Iron Co. in Trinidad district is the same. The elevator delivers to a bin, from which the coal passes through a toothed roll crusher, thence through shaking or rotary screens, in which it is sized. The different sizes pass through washing jigs that deliver the washed coal to a rotary screen, in which it is partially dried. This screen delivers in turn to a disintegrator, the output of the latter being raised to overhead storage bins with a capacity of 630 tons. The waste from the washing jigs is passed to settling basins and is finally drawn off into cars, in which it is hauled to the spoil bank.

The 800 ovens are in a group on the opposite side of the washery buildings from the track hoppers, with 100 ovens in a row and two rows to a battery. These ovens, and all of those in the district are of the bee-hive type, with an internal diameter of 13 ft. The washed coal is delivered from the storage bins at the wash-

mestic consumption and fire protection is available.

The next operation of importance on the Colorado & Wyoming R. R. is at the present terminus of the latter at Tercio, where a large output of coal is maintained, two washeries are erected and 600 coke ovens have been installed. The coal veins at this point are inclined 40 to 60 degrees from the horizontal, so the coal is mined from them in a manner different than that followed in the balance of the operations of the company, where the coal is in nearly horizontal veins. Three entries adjacent to the washeries are at present in service, and a fourth is being opened across the canyon in which the washeries and coke ovens are situated. The adjacent entries are 350 ft. apart, and advantage is taken of the inclination of the coal veins by driving branches from the main entries on the upper side only. The coal can thus be delivered by gravity from the working face directly into cars on a track in the main entry, and in some instances it is delivered from an upper to a lower entry in this manner to reduce haulage. Where necessary, gates are built over the lower ends of the side entries to retain the coal until it can be delivered to the cars.

A tippie has been extended across the canyon, in order that coal may be delivered to cars on the railroad tracks, or to the washeries from the entries on both sides. The coal from the entries on the side adjacent to the washeries is passed through a tippie at the washeries; the coal retained by the grizzlies in this tippie goes into railroad cars, and the balance is delivered directly into storage bins in the washeries. The arrangement and equipment of the washeries is the same as those of Segundo. The 600 coke ovens are in four rows adjacent to the washeries. Washed slack and coal is delivered to them in larry cars operated by gravity in a manner similar to that followed at Segundo. Arrangements are being made, however, to operate these cars electrically and also to install four Covington coke-pulling machines in connection with the ovens.

New power equipment, consisting of a 150-kw. 440-volt alternating-current General Electric generator and a 150-kw. 220-volt direct-current General Electric generator, each of which is direct-connected to a 250-h.-p. high-speed Chuse engine. The 220-volt unit will supply power to operate the larry cars and coke-pulling machines at Tercio. The mine cars, which are now hauled entirely by mules, will be collected and delivered to the mouth of the entries by electric locomotives and then operated on inclines, leading down to the tippie and washeries by wire-rope haulage on electrically-driven hoists. The output of the 440-volt unit will be transmitted to a new mine at Cornell, two miles beyond the present end of the railroad, where it will be utilized by electric hoists and electric locomotives. Steam for the various units in the power station and washeries is furnished by six 100-h.-p. return tubular boilers.

The water supply for Tercio is obtained from a 900,000-gal. storage reservoir, which is supplied from a mountain stream by gravity. Another reservoir site in an adjacent valley will render available a storage capacity of 70,000,000 gal. of water by constructing a dam about 1,000 ft. long and with a maximum height of 67 ft. The construction of this dam will insure an ample supply of water for the present and subsequent developments of the company along the Colorado & Wyoming R. R. Since the average rainfall in the Trinidad district is about 13 in., and as practically all of the normal flow of the streams in this region have been appropriated for irrigation or other purposes, a good water supply is very valuable and is difficult to secure.

The other operations of the Colorado Fuel & Iron Co. in the Trinidad district are all adjacent

to Trinidad. One of the oldest mines is at Starkville, on the main line of the Atchison, Topeka & Santa Fe R. R., five miles south of Trinidad. This mine was opened in 1865 and was operated for years by the railroad company. The slack and fine coal are now passed through a standard washery and utilized in 200 coke ovens adjacent to the mines, while the balance of the output of the latter is delivered to the railroad company. The workings of this mine and of one at Engleville, which adjoins it, underlie an area of about 10 square miles and are believed to be the most extensive west of Pennsylvania. One air course, $7\frac{1}{2}$ miles in length, is in service, and the main hauling entry is $4\frac{1}{2}$ miles long. The mine cars are collected by electric locomotives and delivered to the mouth of the entries by them or by rope haulage. A new entry, 10,200 ft. long and with a maximum grade of 4 per cent., which has recently been opened, will be operated by a con-

furnish steam, and additional boilers will be provided as needed.

The houses for the miners employed in this development are all built of concrete blocks and have stone foundations. Water for domestic consumption and for the power station is obtained by a gravity supply line, $2\frac{1}{2}$ miles long, which terminates in a storage reservoir.

The oldest coke oven plant in the Trinidad district is at El Moro, just north of Trinidad, where 240 ovens have been erected, and 200 more ovens are under construction. The new ovens are to be equipped with electrically operated coke-pulling machines. The slack and fine coal utilized in these ovens is obtained from the mine at Engleville, which is five miles distant. This mine was also one of the first to be worked in the district and is very extensive, having one main haulage entry 9,000 ft. in length and a second haulage entry 6,000 ft. long. Rope haulage systems are operated in both of these



Washery and Tippie at Sopris.

tinuous $\frac{7}{8}$ -in. rope haul driven by an Ottumwa hoisting engine, with 84-in. drums.

The electric locomotives are supplied with power by two 120-kw. Jeffry generators, each direct connected to a 200-h.-p. Ridgway engine. Coke-pulling machines are to be installed at the ovens of this plant and will also be supplied with power by these units. Steam for the engines of the electrical units, the haulage engine and the engine in the washery is supplied by five 100-h.-p. and three 125-h.-p. return tubular boilers.

A new mine that is being developed at Morley, about 6 miles south of Starkville, is indicative of the class of equipment that is being installed in the new developments in the Trinidad district. This development at present consists of an entry on one side and two entries on the opposite side of a narrow canyon, in which the main-line tracks of the Atchison, Topeka & Santa Fe R. R. are laid. A tippie has been erected across the canyon and the railroad tracks, in order that coal may be delivered easily from entries on either side. As one of the entries is on a slope, the mine cars will be hauled in this entry by a steam-driven rope haulage system. In the other entries and on the inside 10-ton Westinghouse electric locomotives will be used for hauling cars.

Two 150-kw. 250-volt direct-current General Electric generators, each direct connected to a 200-h.-p. Chuse engine, are to be installed to furnish power for the locomotives. Four 100-h.-p. return tubular boilers have been installed to

entries, one system in connection with an Ottumwa hoisting engine and the other with a Jackson hoisting engine.

The entire output of a mine at Sopris, four miles southwest of Trinidad, is used in making coke for the steel works at Pueblo, as the coal obtained from this mine is specially adapted for such purposes. The Sopris development, which has been worked for many years, has 276 beehive coke ovens operated in connection with it. The mine cars are drawn to the mouth of the main entry by a rope-haulage system, operated by a Bullock hoisting engine; and thence three-quarters of a mile to a tippie at the washery operated in connection with the coke ovens by a second haulage system operated by an Ottumwa engine. The waste from the washeries is conveyed across a canyon to a spoil bank by an aerial tramway having a 1,600-ft. span.

The principal remaining operation of the Colorado Fuel & Iron Co. in the Trinidad district is at Berwind and Tabasco, 17 miles northwest of Trinidad. Coal is mined extensively at Berwind, and the slack and fine coal delivered to a coke oven plant at Tabasco, which is $1\frac{1}{2}$ miles from the mines. The latter is operated with electric locomotives for collecting cars and with a rope haulage system in the entry. A power station containing six 100-h.-p. boilers and three 120-kw. Jeffry generators, each belted to a McEwen engine, is installed at this mine.

A washery with a capacity of 1,000 tons in 10 hr. is operated in connection with the coke oven

Camps or towns of unusually good character have been built and are well maintained by the company in connection with each of the developments which have been mentioned. This has been done, notwithstanding the fact that building materials are very expensive in the practically barren country in which the district is located, because experience has shown that laborers of the class available for work in the mines will not provide even reasonably decent quarters if left to themselves. In the older camps the houses are generally frame on stone foundations, but they are built along regular streets and are kept in good condition. The concrete block houses in Morley are an example of more recent construction. Water is piped to all parts of each town, and connections are provided for domestic service, with hydrants for fire protection. Good

A GYROSCOPE FOR STEADYING SHIPS was given a public test last month off the river Tyne on the "Seebur," formerly a first-class German torpedo boat, measuring 116 ft. in length, 11.7 ft. beam, with a displacement of 56.2 tons. The apparatus consists of a heavy fly-wheel rotating about an axis, and carried by a frame which can oscillate about a horizontal axis, the oscillating motion of the frame being checked by brakes. The wheel is one meter in diameter, weighs 1,106 lb. and makes 1,600 r.p.m. and is steam driven. The periphery is provided with blades and works like a turbine, the wheel being enclosed in a casing. In the tests with the gyroscope out of action the roll was about 14 deg., according to "The Engineer," London, while the boat was kept steady with the machine acting.

The double-track viaduct of the Erie & Jersey R. R. at Woodbury, N. Y., crosses Bonney Brook at a height of about 72 ft. and is 590 ft. long between face walls of approaches. It is made with plate girder spans, from 40 to 82½ ft. long, supported on two 40-ft. single towers, one 80-ft. double tower and two single bents. The axle is partly on a tangent and partly on a 2-deg. curve, and the location and design were made difficult by the crossing of the contours at an acute angle, and by the necessity for clearance of the proposed highway and of the existing track and a

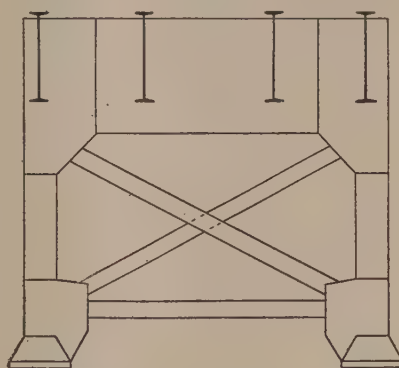
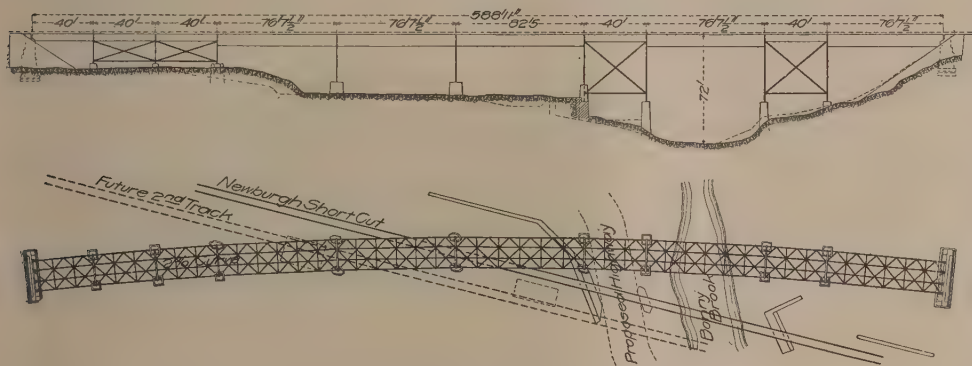
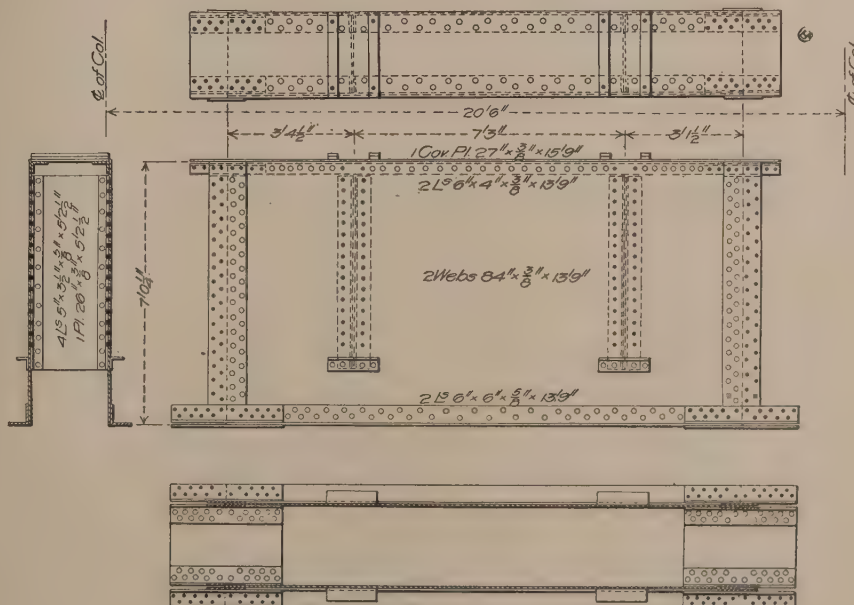


Diagram of Braced Bent.



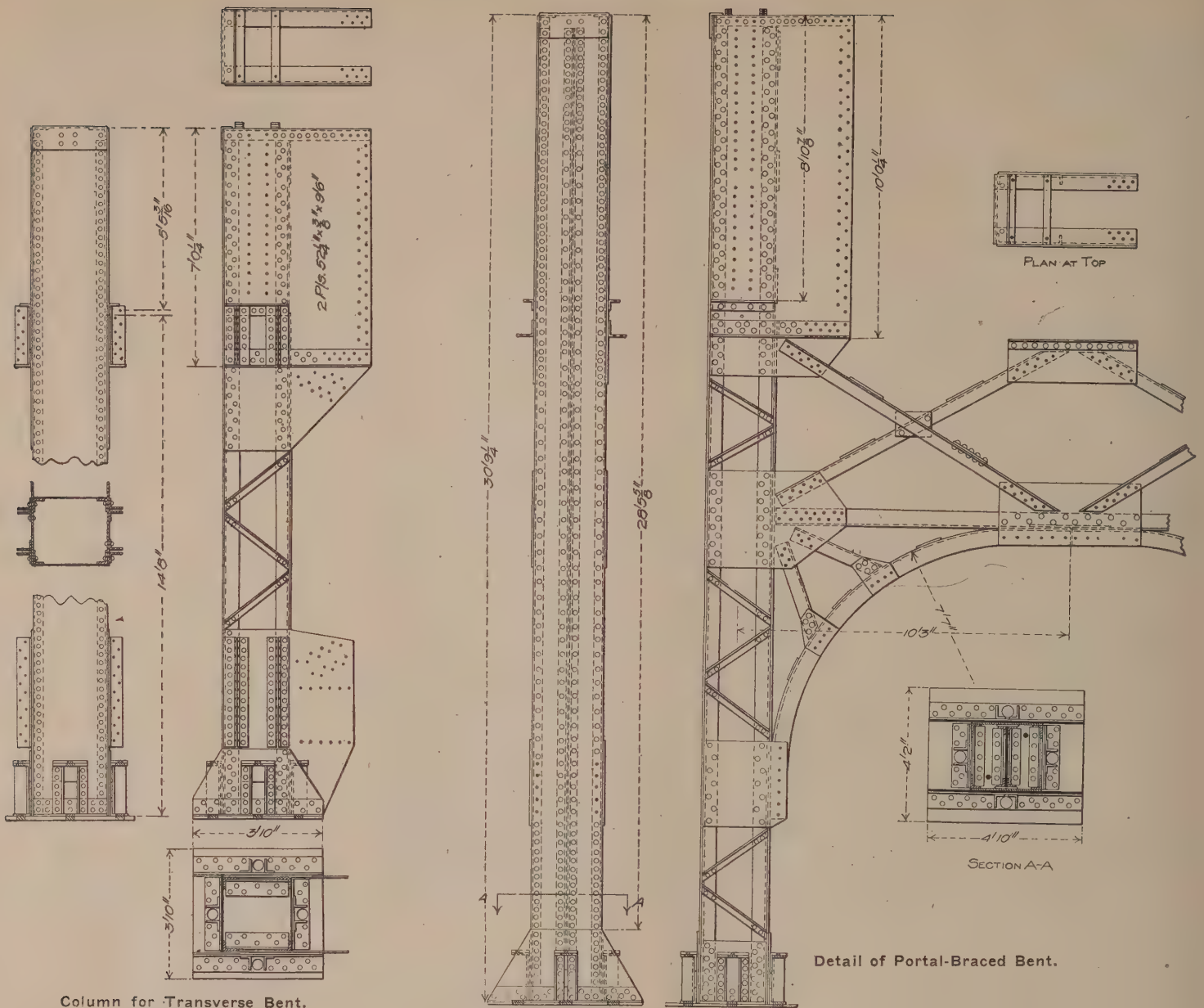
Part Plan and Elevation of the Woodbury Viaduct.

Each column has an I-shaped cross-section, made with two built channels having their webs perpendicular to the axis of the viaduct, and their flanges turned in and latticed, and an I-shaped interior rib, with its web parallel to the axis of the viaduct and its flanges riveted to the webs of the outside channel. Each column is made with four $6 \times 6 \times \frac{5}{8}$ and four $6 \times 4 \times \frac{5}{8}$ in. flange angles and two $27 \times \frac{5}{8}$ -in. and two $24 \times \frac{3}{4}$ -in. web plates. The $50 \times 1\frac{1}{4} \times 58$ -in. base plate is stiffened by two extended flange plates riveted to



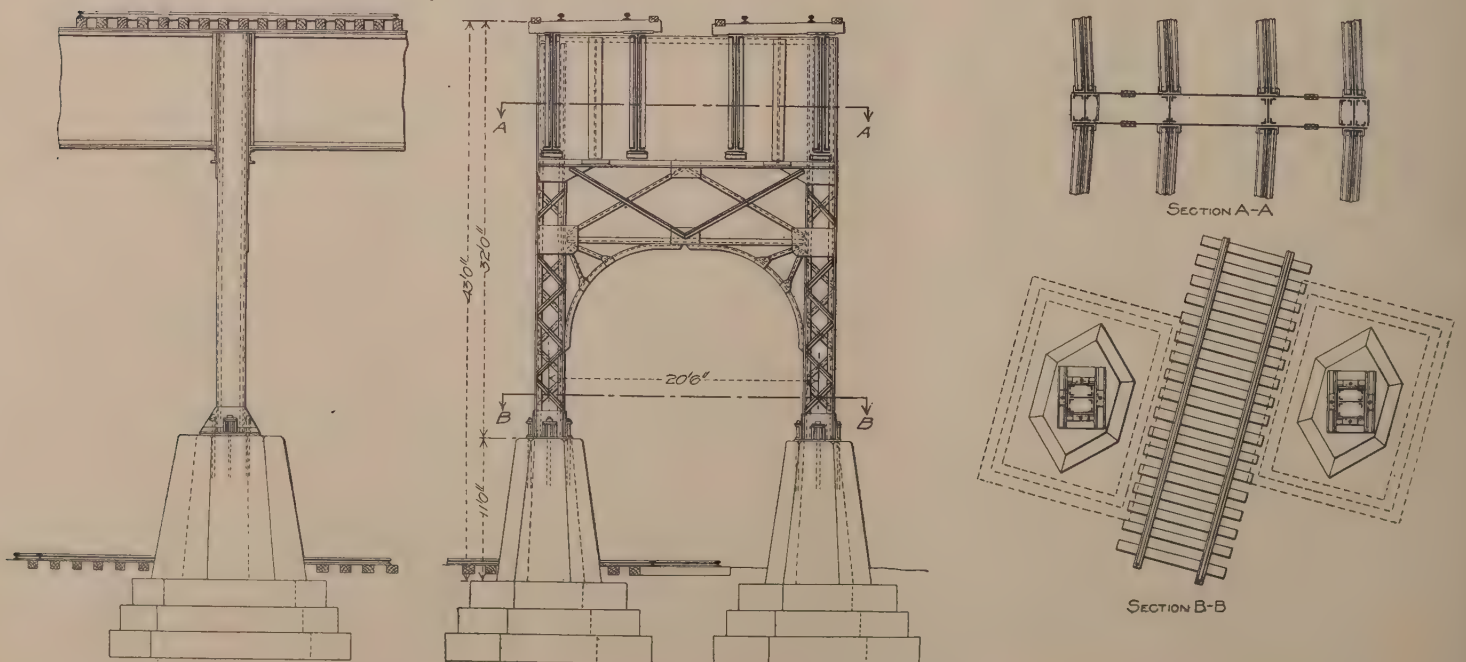
Transverse Girder, Woodbury Viaduct.

the column side plates, riveted across the bottoms of the column flanges, and has four holes for long $3\frac{1}{2}$ -in. anchor bolts, with nuts at their upper end bearing on reinforced shelf angles riveted to the column flanges. On one column the holes through the base plate are 4 in. in diameter, and on the other they are slotted 4 x 6 in. to allow for temperature expansion.



Column for Transverse Bent.

Detail of Portal-Braced Bent.



Portal Bent and Girders of the Woodbury Viaduct.

At the upper end of the column pairs of $5\frac{1}{2} \times 7$ -in., plates 11 ft. 3 in. long are riveted across the flanges projecting on the inner side to form the end sections of the double-web transverse girders connecting the columns. The plates are field-riveted to the ends of the longitudinal girders and to the web cover splice plates of the transverse girders. The portal bracing below the transverse girders is made with pairs of $5 \times 3\frac{1}{2}$ -in. straight angles and pairs of $6 \times 6 \times \frac{5}{8}$ -in. curved angles, all shipped loose and field-riveted to gusset connection plates.

The tower bents are each made with two vertical posts having their tops web-connected to the full depth of the double web transverse plate girders similar to those in the single bents, but different from them in that they have horizontal bottom struts and X-bracing in both longitudinal and transverse panels. The columns have open rectangular cross-sections made with pairs of built channels, with their flanges turned in and latticed, and have wide projecting flange plates to form jaws, receiving the transverse bracing with pairs of vertical connection angles shop-riveted to them to receive the gusset connection plates of the longitudinal bracing. They have $46 \times 1\frac{1}{4} \times 46$ -in. base plates, with anchor bolt connections similar to those of the single bent columns. Each column is made with two 26×7 -in. web plate and four $5 \times 3\frac{1}{2} \times 7$ -in. flange angles latticed together with $2\frac{1}{2}$ -in. zigzag angles having two rivets in each end.

The center sections of the transverse girders are webspliced to the projecting flange cover plates in the tops of the columns and are made with a pair of $84 \times \frac{3}{8}$ -in. web plates 13 ft. 9 in. long and 2 ft. 2 in. apart, with their ends faced to make butt joints with the end sections between the cover plates, which are shop-riveted to them and field-riveted to the column plates. The webs are connected by vertical longitudinal diaphragms in the lines of the longitudinal girders, and the latter have 34 field rivets in each connection, besides being seated, for convenience in erection, on horizontal bracket angles. At the ends of the 76 and 82 ft. spans the transverse girders are similar to those above described, except that they are 10 ft. deep. All of the horizontal and diagonal tower struts have I-shape cross-sections made with pairs of angles back to back latticed; all of them are 2 ft. deep over all to correspond with the width of the post, and one diagonal in each panel is made continuous, while the other is cut to clear it and spliced across it with flange cover plates riveted to both members.

The Erie Railroad's Construction Department is under Mr. J. M. Graham, vice-president, and Mr. Francis Lee Stuart, chief engineer, under whose direction the viaduct, including the foundations, was designed by Mr. Mason R. Strong, engineer of bridges and buildings. The erection will be done by the Bridge and Building Department, under the charge of Mr. W. H. Wilkinson, inspector of bridges. The steel work was fabricated by the American Bridge Co.

THE SURPRISE SIGNAL TESTS made during October on the Pennsylvania R. R. were the most satisfactory ever made. There were 2,245 of these tests and of them 98.8 per cent. were absolutely successful and the remaining 1.2 per cent. were marked deficient merely because the signals were passed only a few feet. Taken as a whole, the October record was 1.2 per cent. better than that of September, the best previous month. Fifteen entire divisions received a perfect rating, while only ten divisions were so rated during September. Five divisions were above 97 per cent. and only one fell below 90 per cent. The skill attained by the trainmen in observing signals is shown by the fact that there was but one failure in the 952 tests on the very busy lines of the Schuylkill division.

The State's Responsibility in Road Improvement.

A paper by Director A. Marston, Iowa Highway Commission, in the "Iowa Engineer," published by the Engineering Department of the Iowa State College.

There is going on at the present time an extended discussion regarding the relative functions of central and local authorities in the government of our country. This is the result of an unconscious movement in the United States toward the centralization of government functions, a movement which has resulted from the necessities of our complex modern conditions. It is found that disjointed, local efforts are no longer sufficient to meet the conditions of the present time. Laws which were entirely satisfactory when our factories consisted of a few hands working with the owner, in close personal relations with him, are no longer sufficient to meet the conditions imposed by the great trusts of today.

What is true of governmental functions in general is also true of the administration of our roads. In the old days the requirements were met sufficiently well by entrusting the entire control and improvement of the roads to local authorities. But at the present time it is believed that the state should assume part of the responsibility, and that an enormous waste and inefficiency result from leaving road administration entirely to disjointed local managements.

The fact is, our country roads have come to occupy a place in the life of our population enormously important as compared with the old conditions. Formerly each farmer was, to a large extent, his own manufacturer and consumer and he used little not produced or made on the farm. At the present time he takes full advantage of the world's factories, commerce, literature, and art, and finds it is economical to leave the manufacture of most of the articles which he uses to the world's factories. The result is that the road which connects him with the nearest satisfactory market has become a vital link in his everyday life.

It has been very commonly supposed that success in agriculture is the result simply of the use of the best methods of cultivation and management on the farm itself, whereas, in reality the successful agriculturist of to-day must take an active part in the transaction of business entirely outside of his immediate farming operations. He needs to know the prices prevailing in the world's markets each day, and to be able to buy and sell at any time of the year, independent of weather conditions.

His intellectual and social life, also, are exceedingly important as compared with former conditions. He must be able to receive his mail every day of the year, delivered at his home. He must be able to procure the best journals and books at will, and in every way must keep in close touch with the intelligence of the world.

In fact, we may say that the radius of the country world at the present day has been enormously enlarged, as compared with former times. Looking back to my boyhood days, I can see the picture of the portion of the world's surface closely known to me, as I presume each man can who was reared in the country. Extending out a few miles in each direction from the home place was a region intimately known to us, and it was mainly with the people living in this region that we had social and business relations of mutual advantage. We thought we were doing well to receive our mail once each week, and if any message was to be given to a neighbor it had to be transmitted by word of mouth. How different are the conditions at the present time! My father, who then seemed to me to be a man of advanced age, now receives his Chicago paper every day, and if he wishes to communicate with

his neighbors he has but to take down the telephone receiver.

Nor should we confine our point of view to the country alone. The modern tendency is toward grouping our population in cities and towns. In Iowa the prosperity of the cities depends mainly upon the magnitude of the territory tributary to them, and upon the regularity and surety with which the inhabitants of the tributary territory can maintain their business relations with the city. Any city which can secure the permanent improvement of the principal roads radiating out from it in all directions, will thereby do much to extend its tributary territory and to insure its business prosperity.

In the investigations of the Iowa Highway Commission of the statistics of the use of Iowa roads, that which has come out most prominently has been the exceeding importance of what might be called the light travel over these roads; that is, their use for other purposes than for the hauling of heavy loads. It is impossible to estimate the money value to the people of Iowa of having good, hard roads at all seasons of the year and under all conditions of weather, for the transaction of the business of the state, and for securing social and intellectual advantages which would otherwise be unattainable.

It is, however, a sad fact that country road improvement has not kept pace at all with the other advances of civilization in America. The present conditions are rapidly becoming intolerable. They constitute what might be termed, and will soon be regarded as, a disgrace to the state.

Yet, we are expending, at the present time, enormous sums upon our roads. The figures for the last three years are as follows:

Year.	County Road Tax.	Township Road Tax.	County Bridge Tax.	Total.
1903	\$547,309.92	\$2,283,129.65	\$1,628,720.88	\$4,459,160.45
1904	559,409.42	1,749,395.23	1,947,423.53	4,256,228.18
1905	518,535.71	1,923,431.81	1,773,304.08	4,215,271.60

Taking into account the money value of the poll taxes, and the sums from other sources than those above enumerated that are expended upon the roads of Iowa, it is probable that the total annual expenditures for road purposes are between \$4,500,000 and \$5,000,000.

To form some idea of the magnitude of this great sum we may compare it with the total expenditures for state purposes in Iowa during the fiscal year ending June 30, 1906, which were \$4,165,639.81. It appears, therefore, that the money expended on Iowa roads in one year is considerably in excess of the total sum required to run the state government, and to support the state asylums, penitentiaries and other charitable and penal institutions, together with the State Normal School, the State University, and the State College.

To administer this smaller fund we elect a state legislature with all its attendant expenses, but as yet Iowa has not taken, as a state, an active part in administering the expenditures of the road funds. Apparently, however, the inevitable force of progress is compelling the state to participate more actively in securing efficient results from its large expenditures on roads.

It is a matter of common knowledge that we do not, under the present system, secure the results to which we are entitled, for the amount of money expended, although our road officers are almost universally absolutely honest, and have the best of intentions. The fault is in the system, in the lack of the training of the men, and not in the men themselves. It will be of interest to inquire what results we could reasonably expect from the money now being spent upon our state roads with proper system, and with thoroughly trained men.

In the first place, we may say that Iowa has approximately 100,000 miles of country roads and that at a maximum expense of five dollars per mile, or a total of \$500,000 annually, these roads

could be maintained in good condition during almost all the year by the proper systematic use of the road drag. If, therefore, our road work were systematized under well trained, responsible men, \$500,000 could be expended each year with results which would be many times more valuable than at present attained with the expenditures of our entire road funds.

In the second place, nearly all the moneys expended for bridges should be put into permanent structures, such as concrete culverts, and steel bridges with masonry abutments. If this policy were followed for a considerable period of years the annual amount required for bridges would greatly diminish. In this way \$1,500,000 to \$2,000,000 could be profitably spent annually for a number of years to come.

In the third place, \$1,000,000 per year could be concentrated upon the improvement of the main traveled roads of the state, including the surfacing of such roads with gravel, broken stone, or other material suitable for making permanent improvement. At prices which have actually realized in the state, this would be sufficient to build 1,000 to 1,500 miles of gravel road per year, two hundred to four hundred miles of stone road.

In the fourth place, there would be left \$1,000,000 to \$1,500,000 for general administration and for grading. The grading done with this fund should be devoted to building good, substantial grades and side ditches, in accordance with road engineer's plans, instead of patching a little here and a little there. Several million cubic yards of earth per year could be moved with this fund.

It is not too much to say that if the administration of the road funds of Iowa were under the management of one of our great railway systems, all the above results would be secured, and that within a comparatively limited number of years we would have a system of roads that would be the admiration of the world, without taxing ourselves any more than we now do. It is impossible, of course, to actually secure such perfect business administration, while still leaving the control of our road funds as closely to the people who pay the taxes as is right and desirable under our system of government. But we should approach much nearer to this ideal than at present. Under the present conditions we see little improvement from year to year, and the money seems to go to just about keep up the roads in their present condition.

To systematize and concentrate our road work must be our endeavor if we would improve present conditions.

Until recently, our state has taken no part in road administration further than to pass uniform road laws. This is a function of state government which has, of course, been recognized in every state in the union. But while the laws are uniform in each particular state, in their administration we find wide difference in practice in different parts of Iowa. There is, perhaps, a more pressing need for an exact and uniform enforcement of our present road laws than for the enactment of new laws. For example, the laws require a proper accounting of road funds, yet we find that the actual system of accounting is often hardly worthy of the name.

Of recent years there has been a general movement in the United States towards more active participation by the state in road administration, and this has shown itself in the creation of state highway commissions. California, Connecticut, Idaho, Illinois, Iowa, Minnesota, Massachusetts, Michigan, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Vermont and Washington have created such commissions. Taking the cases of some of our neighboring states, it may be stated that Illinois appropriates \$50,000 per year for its highway commission; that Missouri has just provided for a state high-

way engineer, with an appropriation of \$12,000 per year for expenses and has further provided for a county road engineer in each county of the state. Iowa has provided that the Iowa State College shall constitute a highway commission, and has appropriated \$5,000 per year, which amount is the lowest provided by any state for its highway commission.

The duties of these highway commissions vary from mainly investigation and advisory work, to active building and maintenance of state roads. The work of our own commission may be said to have just begun. So far, we have been making a thorough preliminary study of road conditions in Iowa, have prepared and distributed road bulletins, have prepared and have been furnishing to road officers standard plans for culverts, bridges, and road construction, have inaugurated an annual road school for the training of road officers, have furnished expert advice to road officers calling for it, both by correspondence and personal visit, and have been endeavoring to assist further in the road work in all ways possible.

Another very important method by which the states of our country have been taking active part in road work in recent years is state aid. Connecticut has available about \$225,000 per year for the construction of state roads, the state paying ninety-five per cent. of the cost. Massachusetts appropriated in 1905 about \$550,000, paying seventy-five per cent. of the total cost. In New Hampshire the amount is \$125,000 per year, the state paying from twenty-five to seventy-five per cent. of the cost. New Jersey, which shares with Massachusetts the honor of pioneering the way in state road construction, expends annually \$400,000, paying one-third of the cost. New York has recently appropriated \$50,000,000 for state roads, to be expended in ten years, and pays fifty per cent. of the cost. Pennsylvania appropriated \$6,356,232, to be expended in five years ending 1909, and pays seventy-five per cent. of the cost. Washington pays fifty per cent. of the cost of all roads built by the state highway commissioner. Michigan pays "state rewards" for gravel and macadam roads, ranging from two hundred fifty to one thousand dollars per mile, according to the kind of road built, when same have been constructed according to the plans and specifications of the state highway commissioner and have received his approval.

While there might be much doubt in the minds of many people whether as yet Iowa has reached the time for extending state aid for hard roads, yet all who have studied those built under this system in our eastern states must admit that they are the finest roads in the world. And the plan is so popular with the tax-payers who foot the bills that in every state having such a system there are continual demands for the construction of many more such roads than can possibly be built. At the same time those making the requests understand that they have personally to pay a large part of the cost in addition to the amount paid by the state. The macadamized roads built by New Jersey, Massachusetts and New York under the system of state aid road construction are ideal, and are unsurpassed in the world, whereas, a few years ago these same states had roads equal to the worst.

In conclusion we may inquire what can be done in Iowa by the state to secure better roads. I will enumerate certain things which we believe our state could well undertake.

In the first place the state should systematize our road work.

(1) Its highway commission will supply to all road officers desiring them standard plans for culverts, bridges and road construction. We believe the state should require that all plans and specifications for large bridges be submitted to and approved by the commission, and that the con-

struction of culverts and roads should, in general, be carried out in accordance with standard plans.

(2) The highway commission should supply road experts to respond to the call of road officers for advice and assistance.

(3) The state should by law provide for a road engineer in each county of the state, who should be a trained and well qualified road expert, who should make surveys and prepare plans for all important road work, and under whom in general the road work of the county should be placed. These county road engineers should be required to make regular reports to the highway commission, and to keep in close touch with it.

(4) The local road officers of each township should be required to make regular reports to the county engineer, and in general to work in consultation with him.

(5) Means should be provided for educating and training road officers. The present Road School should have its facilities for such work greatly extended and, if necessary, should hold a number of sessions each year in different parts of the state, so as to make it more convenient for road officers to attend.

In the second place our present road funds should be expended in such a way as to secure better results for the money.

(6) Systematic dragging of all earth roads, except unused byways, should be required, and should be carried out under road officers who can be held responsible for results.

(7) The expenditures for culverts should be devoted mainly to the building of permanent concrete structures.

(8) All large steel bridges should be built in accordance with definite plans and specifications prepared by competent engineers and let to the lowest responsible bidder, after being properly advertised.

(9) The county road fund should be increased one mill, and in general the road work should be to a considerable extent concentrated on main traveled highways.

(10) Wherever practicable, a beginning should be made at surfacing the principal roads with the best gravel or stone or other hard material locally available.

In the third place, the state should by direct appropriation provide for the building by the State Highway Commission of sections of experimental road in different parts of the state. In no other way can the best materials available in Iowa be discovered and the cost of good roads construction be ascertained.

The road question in Iowa is one of the most important to be solved by our people. The traffic on these roads is so large that if teams could be collected in one string to do the annual traveling in one day, at thirty miles per day, this string of teams would reach more than one and one-half times around the entire earth. In every way is the attainment of good roads most vital to our people. We must believe that the problem will be successfully solved in our state, and that Iowa roads, as well as as Iowa agriculture, will in the future be found in the first rank.

A HYDRAULIC DREDGE designed for the removal of 4,500 tons of sand per hour from a depth of 70 ft. below water level has been built by Ferguson Brothers, Port Glasgow, Scotland, for dredging the Thames estuary. The spoil will be carried in hoppers aboard the dredger itself until ready for discharging. The vessel is twin-screw, 330 ft. long, 55 ft. 6 in. wide and draws 23 ft. There are two suction pipes, connected to Gwynne centrifugal pumps. The work to be done consists in constructing a channel 1,000 ft. wide and 30 ft. deep at low water through Leigh Middle Shoal, the total being about 6,000,000 cu. yd.

A Few Tests and Experiments with Reinforced Concrete.

By R. T. Surtees, C. E., Newton-le-Willows, Lancashire, England.

During the last few years, reinforced concrete for building and engineering works has made such headway that the limits of its application appear almost boundless. Construction of great intricacy and daring has been successfully carried out with it, whilst the failures have been few, those that have taken place being traceable to the inexperience or carelessness that may be found in all departments of works and labor. It is no doubt a material, or system of building that requires a considerable amount of care to ensure success, and whilst the principal amount of labor in connection with it may be got from the unskilled, the leading hands should be experienced and able to see the object of the designer and ensure it being carried out. Care should be taken in the selection of proper materials, according to the work required of them,

ing a correct answer to these questions, so far as the aggregate or the concrete is concerned, and to many, I am afraid, the results will be in one or two instances, not quite what might be expected.

With aggregates of various materials, concrete blocks were made up in which were inserted pieces of steel, with their ends projecting out of the mass for a few inches. These blocks were immersed in water at frequent intervals, for a period extending over twelve months, when the projecting ends of the steel were found to be highly corroded. They were then submitted to the action of steam from a boiling solution of acid, until the exposed steel was, in most instances practically destroyed. The blocks were then cut open so that the embedded portions of the steel could be inspected. Fig. 1 is from a photograph of some of these blocks, the concrete in which was made with an aggregate composed of blast furnace slag from the works of the Wigan Coal & Iron Co., Lancashire. Figs. 2 and 3 show other blocks made with boiler fur-

steel to the outside of the blocks when examined.

The whole of the concrete used was made with aggregates containing the run of the crusher, none of the fine dust being kept out.

These experiments indicate that to preserve the steel effectually the aggregate for the concrete should be carefully graded to ensure the filling of the voids, that the concrete should be carefully mixed, placed, and consolidated, and even if this mixture does contain certain chemical impurities, there is small likelihood of rust being formed. Great care should be exercised to prevent the possibility of air spaces, honeycombs, or cracks on the outer surface extending into the mass far enough to allow an air passage to reach the steel, for if unnoticed or allowed to remain, rust will form, which may burst off part of the concrete, and so weaken the structure that disaster will eventually result. A case which recently came under the writer's notice was caused by the timbers being removed by the workmen before the concrete had been properly set, when its own weight had caused



Tests of the Permeability of Concrete and the Protection of Steel.

and it is surprising what useful tests can be made at a cost warrantable for jobs of comparatively small dimensions. The writer was once nearly led into disaster by what appeared a hard gravel, apparently admirably suited for concrete, but on leaving a handful near a warm steam pipe, was surprised to find after a few hours, a number of cracks in each piece, so very small as to look like fine hairs. On breaking them up they were found to be nodules of clay encased with a thin coating of hard material, and it required only a comparatively small rise in temperature to cause them to burst, making them most dangerous to use for concrete. Failures have been reported from concrete made with aggregates containing a small percentage of sulphur, such as is found in certain blast furnace slags, etc., but it is doubtful as to what was the precise cause, and perhaps if careful and intelligent investigation had been carried out, it would have been found to be due to the imperfect proportioning and mixing of the materials and not to the constituents.

It has been found that iron cramps after being surrounded with concrete for hundreds of years, have been proved to be in perfect condition, whilst it has been equally proved that steel embedded in concrete floors, for only a few years has been affected to such an extent that the wonder was that a collapse had not taken place.

What is the cause of this great difference? Is it the chemical composition of the steel or the aggregate, or is it due to the mixing and placing of the concrete? The following experiments have been carried out with a view of ascertain-

nance clinker, crushed bricks, and a mixture of brick and clinker, included in Table 1, which also gives the results of the experiments:

TABLE 1.—EFFECT OF WATER AND ACID VAPOR ON STEEL IN

No.	Aggregate.	CONCRETE.		Remarks.
		Sulphur.	Over Steel.	
1	Slag	2.07	1 3/4	Steel unaffected
2	"	2.07	1 3/4	" "
3	"	....	1 3/4	" "
4	"	....	1 3/4	" "
5	"	....	1 3/4	" "
6	"	2.07	1 3/4	" "
7	"	2.07	1 3/4	" "
8	"	....	2	" "
9	Clinker	....	2	" "
10	Brickbats	....	2	Corroded from honeycomb in concrete.
21	Clinker	....	1 3/4	" "
23	Brickbats	....	2	" "
25	Br'k. and clin.	....	2	" "
27	Brickbats	....	1 3/4	" "

In Nos. 2, 3, 6 and 7, the bars were nearer the outside of the blocks than is usual in reinforced work, and yet nothing penetrated the concrete far enough to cause rust to form on the steel.

The amount of sulphur in Nos. 1, 2, 7 and 8 was sufficient to color the concrete to a dark green, and there appeared to be no deleterious action set up on the steel.

There was a large amount of iron in the clinker which did not show any effect on the embedded steel when the concrete was properly consolidated and without voids.

In all cases where the steel showed corrosion, the concrete had not been properly graded, or made free from honeycombs or voids, which in most cases were easily traceable right from the

it to fall away from the steel just enough to cause a crack extending a considerable distance along the rods. No attempt had been made to remedy this, and after the contractor had handed over the work, the evil results began to appear. In a case of this kind, the rusting of the steel may perhaps not be the least danger incurred, for the concrete might be materially damaged, whilst its adhesion to the steel would be far from what it ought to have been.

Cinders, pan breeze and such like are undoubtedly attended with a certain amount of danger in their use as aggregates in concrete having direct contact with steel. When soft they will not stand ramming without crushing, and the crushed parts may not be coated with cement, consequently dampness may make through to the detriment of the steel. Cinder concretes have no doubt been the cause of failures, and in the hands of careless contractors are most dangerous to allow. A concrete made with them may, however, with advantage be used under certain floors, or in partitions where it is required to take nails for fixing boards or other timbers. It is also a poor conductor of sound and useful as deafening.

Under no conditions is a rich concrete, having an aggregate of hard, sound material, proportioned and placed so as to secure the greatest density, more necessary than for an impermeable concrete. A concrete of this kind is often required for cellars, reservoirs, tanks, pipes and such like. Fig. 4 shows a method of carrying out experiments with a view to securing the best results, the apparatus being of simple construc-

tion, will allow the test to be carried out on most jobs at little expense. In each of the four large pipes shown are blocks of concrete, 5 in. in thickness, moulded inside. The larger pipes are connected to the town's water supply by means of the small pipe along the top, which allowed a pressure of 40 lb. per square inch, means being provided to allow the enclosed air to escape. The arrangement shown is also connected to a small boiler feed pump by which the pressure could be increased to 260 lb. per square inch, the town's pressure being shut off by a small valve when this was being applied. Table 2 gives the composition of the concrete in each pipe.

The aggregates included the fine stuff contained in the whole run of the crusher. The pipes were allowed to stand under damp cloths for two days, and afterwards were immersed in water for eighteen days, the test being applied on the twenty-first day after the concrete was placed. The results of the tests are given in Table 2.

TABLE 2.—PERMEABILITY TESTS OF CONCRETE.

Number	1	2	3	4
Gravel, uncrushed, parts	2½	3	4	3
Gravel, crushed, parts	2½	3	2	3
Sand, parts	3	2	2	2
Cement, parts	2	2	2	2
Screen for gravel, in.	¼	¼	¾	¾

Date After Applying Pres.	Press. in lbs. per sq. in.	Leakage in Centiliters per hour.
1	35-50	5.37
2	35-50	20.00
3	35-50	12.00
4	60-70	30.00
5	35-50	14.66
6	35-50	7.50
7	35-50	6.00
8	35-50	7.57
9	35-50	6.00
10	35-50	5.83
11	35-50	5.25
12	35-50	6.00
13	35-50	6.33
14	35-50	5.83

NOTE: The tests were continued at about the last rate until the thirtieth day, when the experiment was considered finished.

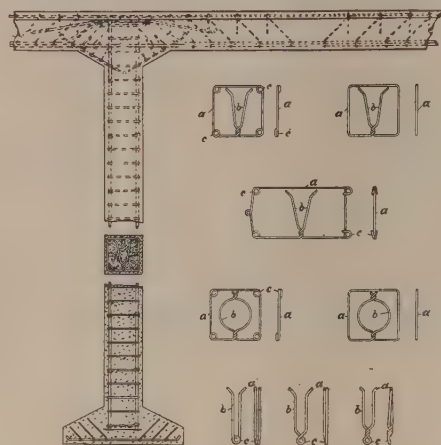
Having proved a satisfactory mixture, from the materials to hand, an attempt was next made to find out the best conditions under which the concrete would set, for should contraction take place, cracks might occur, through which water could pass. With this object in view, four more pipes were used, in each of which was placed a thickness of 5 in. of concrete, prepared in a similar manner to those giving the best results in the preceding experiment. No. 1 was placed in a position to set where a hot sun could get at it during most part of the day, No. 2 was placed in a shaded place, and Nos. 3 and 4 were allowed two days under a damp cloth, twenty-eight days immersed in water, and all were put under pressure on the thirtieth day. The concrete in No. 1 had contracted in setting as water passed between the pipe and the block of concrete inside. No. 2 showed a very slight dampness which soon took up, while Nos. 3 and 4 were perfectly watertight. The set of pipes shown in Fig. 4 were made up of Nos. 3 and 4 of the former experiment, renumbered respectively 1 and 2, with Nos. 3 and 4 of the latter. The pressure was again applied, being gradually increased up to 260 lb. per square inch, and after two days with it varying between 50 lb. per square inch and this. During this time no signs of dampness appeared on the underside. One of the blocks was cut out to see how far the water had penetrated into the mass of concrete, where it was seen to be traceable for a distance of only 1½ in. Whilst it may not be a difficult matter to make blocks of this size to stand such high pressures, it could hardly be expected that a long, thin wall of the same materials would give the same results, there being so many other factors to contend against.

Following this investigation a step further, a reinforced concrete pipe was made, as seen in

Fig. 5. This was first made with an open end, and after the concrete had set, a short length of cast iron pipe,—for a special purpose other than connecting the hydraulic pressures—was moulded on to the end, the longitudinal steel reinforcing rods passing through the pipe and well into the concrete securing the cap. After connecting up the pipes, pressure at the rate of 30 lb. per square inch was applied, being gradually increased until it reached 120 lb., with no signs of dampness appearing on the outside of the pipe. This pressure was maintained for three hours, and on attempting to raise it higher, the joint between the first-made concrete and that fixing the cap gave way; as the object of the experiment had been attained, no further attempt was made to reconnect it.

Reinforced concrete pipes without the assistance of internal metal tubes to stand a pressure of this severity require great care in their construction, and a little remissness in mixing, placing or consolidating the concrete may lead to failure.

To secure the best results under direct compressional loads, as in columns and such like structures, it is imperative that the main or vertical reinforcing bars should be so fixed as to secure the requisite size of core, to be hooped or bound with a wire, wrapped spirally around the steel skeleton, to the bars of which it may be tied

Fig. 6
Types of Hooping Tested.

with fine wire; or, with wire hoops, or with links. Hooping may consist of horizontal hoops, welded, bolted, or riveted at the ends to form a continuous band to the shape of the column, or wires may be used having their ends twisted to form a secure fastening. These are placed around the vertical bars, at proper intervals, in accordance with the strength demanded. Encircling fittings added to a few of these forms of hoops, to hold the bars in their exact position, are well worth the little extra expense, as they serve both to connect the bars together and hold them apart from each other, so that the core cannot be otherwise than the size and shape designed.

The spirally wrapped skeleton has often been thought one of the strongest systems, but is difficult to apply, and as the whole skeleton has to be built up in position before any of the concrete is placed, it makes this difficult to do. What may be gained in a stronger skeleton may be lost in weaker concrete; and should the continuous wire wrapping get damaged at any one place in its length, it materially weakens the whole structure, whilst one break in it practically destroys the whole length of hooping. With any form of skeleton, however well it may be made, care is required in ramming the concrete, and care should be taken to ensure as little obstruction as possible to this part of the work.

Even if the steel is made up into units, they may be thrust out of place by careless workmen who do not realize the importance of what they are doing. It has been contended that the advantage said to attend a spirally wrapped hooping lay in the fact that the spaces between the spirals were not in the same horizontal plane right round the column, as in the case with plain link hooping. This is doubtful, nor does the following experiments bear this out.

The arms of the hoop were arranged, see Fig. 6, in the mass of concrete in different directions to those of the next adjoining hoop, thus further reinforcing the core against that bulging action which is always set up when the load is applied. It is also probable that the horizontal hooping, as heretofore tested against wire wrapping, may have had the ends of the links simply laid side by side in the concrete, as was formerly the common practice, instead of having them securely twisted to form a tie, which ensures a structure being fully 23 per cent. stronger. It may be a comparatively simple matter to keep the steel members in their correct position in making a small test piece, but in actual work the difficulty is great, as every worker in reinforced concrete knows. Instances have been found where the steel members have been found to be far different to where the designer intended they should have been placed, and even in test pieces where every care has been taken to ensure correct work, members have been discovered out of place. Systems giving simplicity in design and execution, with secure fixing of the steel as the work proceeds have much to commend them.

It cannot be expected to make a structure of greater strength than its component parts, therefore, we may look to get the best results under compressional loading, with a concrete having an aggregate of the hardest materials.

Figs. 7, 8, 9 and 10 show a set of columns made as nearly as possible under identical conditions as regards aggregates, sand, mixing, placing and consolidating the concrete, special efforts being made to ensure that the whole should be as uniform as possible. Fig. 7 and 8 had the longitudinal bars spirally wrapped and Fig. 9 and 10 had horizontal hoopings, as illustrated in Fig. 6, the steel in each instance being of the same weight throughout. Fig. 7 is of particular interest, inasmuch as it indicates a peculiar twisting action, which is perhaps attributable to this form of hooping when under load. As it happened, the pin which holds the table of the testing machine in position, had been accidentally left out, thus leaving it free to move on its pivot, and after the application of the pressure, the column began to twist to failure, the table moving around in unison therewith, destruction being achieved with a load of 49 tons. Fig. 8 was tested with the table fixed and failed under a load of 55 tons. Fig. 9 failed under 85½ tons and Fig. 10 under 91½ tons. The specimens were all 2 ft. 6 in. long by 8 in. square.

Figures 11, 12 and 13 and Figs. 14, 15 and 16 illustrate respectively two sets of columns, the experiments being carried out as before, the concrete being prepared and the work executed with a view to securing uniformity throughout. The longitudinal bars were 13/16 in. in diameter in all cases, there being a slight difference in the spacing of the hoops, which were of the link and strut pattern.

No.	Crushed at.	Length.	Size.
11	134½ tons	3 ft.	10 x 10 in.
12	176 "	3 "	"
13	209 "	3 "	"
14	219 "	4 "	"
15	197 "	4 "	"
16	215 "	4 "	"

It will be seen that Fig. 14, which is made with concrete having no reinforcing steel in it, comes out stronger than any of the others. In

this case the failure took place suddenly and with a loud report, as of an explosion, whilst pieces of the concrete flew about the room with dangerous velocity. It is undoubtedly one of those freaks which sometimes develop even after the greatest care has been devoted to the work of construction. In this case the whole of the details connected with their construction were

ency, and that there be no obstruction to its, efficient consolidation, such as jarring after it has begun to set.

The mixture used in the manufacture of the last two sets of columns, was just something less than a wet one, and with those having the steel skeleton in the moulds, the concrete could not be so thoroughly rammed as where there was no

Concrete in Bags.

Bags of concrete are often used in constructing foundations under water, but caution should be exercised, Mr. W. D. Cay states in "Engineering," to see that the projecting ends of such bags are not subjected to the pounding of a heavy sea or its equivalent. In his opinion there



Method of Failure of Reinforced Concrete Columns.

personally supervised by competent engineers representing three different authorities.

If it were possible, in actual work, to consistently obtain a concrete of this superior quality and strength, reinforcing would not be so much necessary. After breaking, the sample of concrete showed to be very dense, with practically no pinholes in it, and hundreds of attempts might be made to make another to give such good results, without success. It shows the advantage of having the soft concrete of the right consist-

such obstruction. A bigger rammer could also be used. It is undoubtedly due to these causes that such a high result was obtained in this particular specimen. Fig. 16 shows excellent design and construction.

In the columns comprising the last six experiments, the concrete was mixed in a machine of the revolving drum type, which, after repeated tests, the writer is convinced, made a concrete which was 16 per cent. stronger than could be turned out by hand mixing.

must be ample mixing facilities, the materials must be collected close to the hoppers of the mixers, and large cars or skips used to transfer the concrete to a box in a hopper barge, in which the bag has previously been placed. The barge should be taken rapidly to the site of deposit, the bag being sewn up during transit and when brought into position the pulling of a trigger releases the doors of the box and the bag falls slowly down through the water to its place.

The Harlem Creek Sewer, St. Louis, Mo.

The Harlem Creek sewer, in St. Louis, Mo., is being constructed to carry to the Mississippi River the combined domestic sewage flow and storm-water run-off from a residential section of 6,000 acres in the northern part of the city. The area which will be served by the sewer lies about a mile back from the river, and between it and the latter is a stretch of low, flat river bottom land that is only slightly above extreme high water in the river. Back of this bottom land the country is considerably rough and broken, but is fairly well built up as a residence district. The storm-water run-off accordingly reaches the drainage outlets quickly, thus requiring large sewers to carry it away.

The Harlem Creek sewer has a total length of approximately a mile, extending from an outlet in the low area, about 1,500 ft. from the foot of the higher ground, back up into the hills for nearly 3,700 ft. The sewer has a semi-circular arch, with a flat, inverted semi-circular arch invert, and is built of reinforced concrete. In the first 1,000 ft. from the outlet the intrados of the arch has a radius of 14.5 ft. and the invert a radius of 29 ft. In this length the cross section of the sewer has an area of 411 sq. ft., giving a hydraulic radius of 6.41 ft., and the sewer is laid on a grade of 3 in. to 100 ft., which produces a velocity of 18.9 ft. per second and a carrying capacity of 7,480 cu. ft. per second. The arch of the sewer in the next 1,400 ft. has a radius of 13.5 ft., and the invert of 27 ft., the cross-section being 379 sq. ft., the hydraulic radius 6.2 ft., the velocity 18.2 ft. per second and the carrying capacity 6,714 cu. ft. per second. The remainder of the sewer has an arch with a radius of 12.5 ft. and an invert radius of 25 ft., the cross-section being 327 sq. ft., the hydraulic radius 5.76 ft., the velocity 17.8 ft. per second and the carrying capacity 5,570 cu. ft. per second.

Since the sewer is over a mile in length and has such a large section, the saving of the smallest quantities per linear foot results in a very considerable economy in the structure as a whole. A semi-circular section was selected because of the simplicity of form work required for it, of the determination of waterway areas, and of the belief that all uncertainties of loading considered, it would come as near being the economical form as any that might be designed.

The low area which is crossed by the sewer will doubtless eventually be occupied by railroad yards, as it is crossed by several trunk lines, which already have considerable yard facilities in this area. A switch track also extends from these yards up the valley that is occupied by the sewer. The latter was accordingly designed to carry the loads that will be brought on it by these tracks. The selection of a conduit section on the basis of loading alone necessarily involves some definite assumptions as to loads. They must be considered either vertical, or partly vertical and partly horizontal, and if so, the ratio of the horizontal to the vertical must be assumed. The variation in the height of fill, the nature of the filling material, the manner of placing, the amount of moisture and so forth all affect these assumptions to such an extent as to make a selection on such a basis rather impracticable. The largest section, with a 29-ft. clear span, was assumed to have a 15-ft. fill over the top of the arch, and also to carry the heaviest railroad loading combined with a 7-ft. fill. In order to provide for the most unfavorable condition of back filling, the loads were assumed to have such position as to produce maximum bending moments without regard to continuity. It was found that this method in the case of the 15-ft. fill also provided amply for the railroad loads.

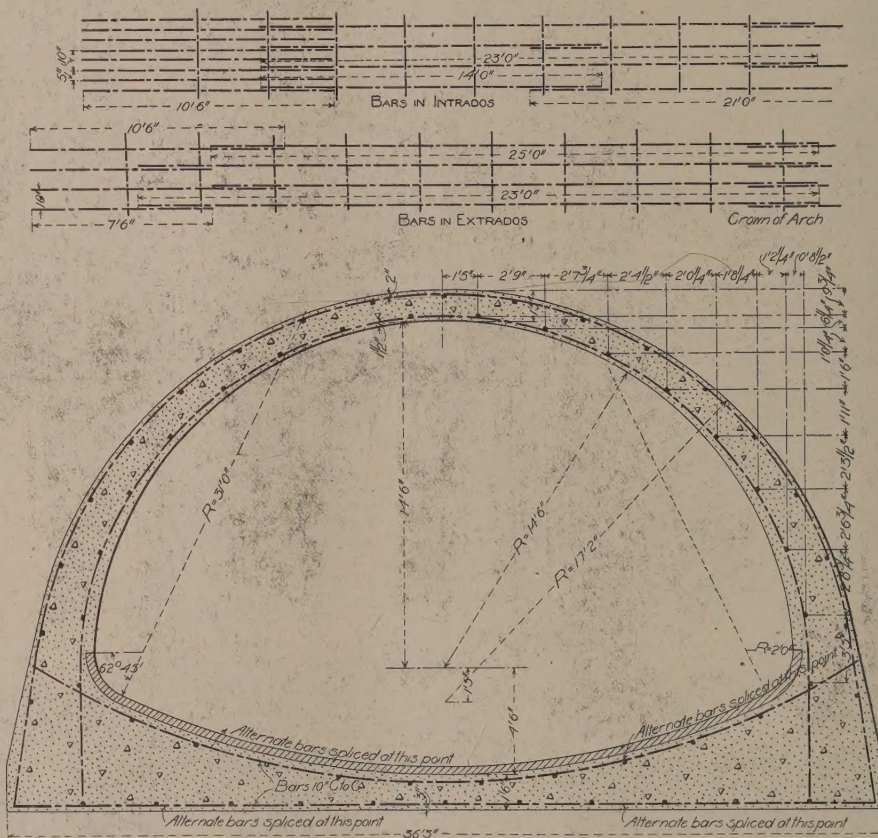
The stresses in the various sections were determined from the analysis of circular ribs with fixed ends in Prof. Chas. E. Green's treatise on arches. The determination of constants for the horizontal forces had to be made from the general equations and involved considerable labor, but the work proved very much worth while, as the horizontal forces were found to reduce the bending moments from the vertical loads. To illustrate this point: The bending moment at the crown of the 29-ft. arch, due to vertical load, was found to be about 208,000 in. pounds, but of the opposite sign, leaving a resultant positive bending moment, which results in a tension in the intrados of the arch of about 108,000 in. pounds, or a reduction of nearly 50 per cent.

The advantage of reinforced concrete over plain is considered to be very clearly shown by

portion of 1 part Red Ring Portland cement, 3 parts river sand and 6 parts crushed limestone, the pieces of which vary from $\frac{1}{4}$ in. to 1 in. in size. In ordinary soil about 4 cu. yd. of this class of concrete was required per linear foot of sewer. The arch concrete was made in the proportions 1:2:5, 2 cu. yd. per linear foot of sewer being required. The proportions of the two mixtures are varied to suit the percentage of voids in the sand and broken stone.

The details of the reinforcement of the sewer section are clearly shown in an accompanying illustration and need little explanation, Johnson corrugated bars being used for reinforcing. All transverse reinforcement is made with 1-in. bars, and all longitudinal reinforcement with $\frac{1}{2}$ -in. bars.

The construction of the sewer presented no



Reinforcement in Maximum Section of Harlem Creek Sewer.

the stress conditions existing at the crown. The resultant bending moment being 108,000 inch pounds, while the total thrust was but 18,000 lb., gives an eccentricity of 6 in. To keep the thrust inside the middle third, or to cause no tension, would therefore require a thickness of about 36 in. But assuming a section of reinforced concrete 15 in. thick, the combined stress due to thrust and bending moment would be:

$$f = 108,000 \div (12 \times 15) \pm 6 \times 108,000 \div (12 \times 25) = 100 \pm 240.$$

The stream carrying capacity required for the sewer was obtained by McMath's formula for determining run-off, which is $Q = p^2 V (A's)$; Q being the quantity in cubic feet per second; p , the percentage of the total rainfall in inches; A , the area in acres and s , the slope of the surface. It was assumed that 75 per cent. of the rainfall would reach the sewers and that the maximum rate of rainfall would be 2.75 in. per hour. In estimating the carrying capacity of the sewer, n in Kutter's formula was assumed to be 0.013 for the brick lining, which is provided for the invert of the sewer.

The concrete in the invert and up to the springing line of the sewer was made in the pro-

special difficulties, the sewer extending down the valley of a small crooked stream, which carries a large volume of water during floods, but is very low during dry seasons. The channel of the stream is cut across several times to avoid curves in the sewer. The construction has been handled in alternate sections between these crossings, in order that the flow of the stream might be handled easily. The extrados of the sewer is from 4 ft. to 20 ft. below the natural surface until the edge of the low area is reached and across that area filling has to be provided in places to cover the sewer. As the trench has to be opened 2.5 ft. wider on each side than the base of the sewer, or to a total width of 41 ft. in the large section, it involves a large amount of excavation. Across the portion of the low area in which construction was carried on the soil is river silt to a depth of a few feet, under which is a stratum of limestone; in the higher ground the soil covering over the limestone is considerably thicker. The preliminary estimates indicated that 13,000 cu. yd. of rock and 50,000 cu. yd. of earth would have to be moved in building the sewer. It was also expected that considerable quicksand would be encountered, but at the time these notes were prepared no difficulty had been

experienced from this source. The earth excavation has been made by hand, the excavated material being handled out of the trench in buckets by stiff-leg derricks. The limestone rock, which is of an excellent quality and is crushed for use in making concrete, is loosened by blasting and stored along the sides of the trench. The contractor has installed a No. 3 Gates gyratory crusher in which the rock is reduced. The output of this crusher is raised to an elevated storage bin by a bucket elevator which delivers to a screen that separates the stone into the following three sizes: screenings, $\frac{1}{4}$ -in. to $\frac{1}{2}$ -in. pieces and $\frac{1}{2}$ -in. to 1-in. pieces. The screenings are not used in the concrete, sand being employed for the fine aggregate.

Mr. H. F. Fardwell is sewer commissioner, and Mr. J. A. Hooke is assistant sewer commissioner of St. Louis, in charge of the construction of this sewer.

Letters to the Editor.

COST OF ENGINEERING WORKS.

SIR: I read with deep interest your editorial on "The Cost of Engineering Works," and thoroughly agree with you that it is unjust and unfair to attempt "to discredit the evidence of an eminent engineer of twenty to forty years' active professional work," and such an attempt to so discredit such an engineer should be frowned down upon by the entire engineering profession.

When, however, an eminent engineer, goes upon the witness stand as an expert, he cannot object to inquiries as to the exact nature of his "active professional work," and upon which he bases his expert opinion. In a recent case which came under my observation, one such expert, of high standing and reputation, had actually no construction experience for over twenty years in which he was responsible for the results obtained, and his memory of his experience prior to that time proved to be extremely hazy. It will perhaps not be denied by anyone that in the engineering profession construction methods have somewhat progressed during the last twenty years.

Very truly,

ALEXANDER POTTER.

New York, Dec. 2.

CONCRETE COKE OVENS.

SIR: In reference to a letter in your issue of Nov. 16th upon the subject of "Concrete Coke Ovens," during the winter of 1906-7, the writer designed and supervised the construction of 350 beehive coke ovens, which are probably of the type referred to by your correspondent. In these ovens the ring wall foundations, larry-track columns, and battery retaining walls are of concrete, the ovens and oven floors being of fire brick. The battery retaining walls are 12 in. thick and reinforced with plain round rods. The observed temperatures on the outside and inside of this wall were 120° and 250° Fahr., respectively. It is not probable that the inner face of the wall is ever subjected to a higher temperature than 400°. Laboratory tests would indicate that concrete is improved rather than injured by a steady heat of this temperature.

The ovens are the property of the Carbon Coal & Coke Co., of Trinidad, Colo., a subsidiary concern of the American Smelting & Refining Co., and were first fired up in August, 1907. No bad effects have been observed to date and the writer sees no reason why ovens of this type should not come into general use wherever a considerable number of ovens are to be built at one time.

Very truly yours,

LINDSAY DUNCAN.

McGill, Nev., Nov. 26.

STEAM TURBINE ECONOMY.

SIR: Permit me to verify the statements made in your issue of Oct. 12, in connection with an economy test on a large turbine of the Parsons type at the station of the New York Edison Co. The accuracy of the results has been called into question, and I therefore desire, first, to uphold the accuracy of your published reports, and, second, to correct a popular misconception regarding comparison of turbine economies under different operating conditions.

The point at issue is whether the water rate of 14.9 lb. per kilowatt-hour, developed by the New York Edison turbine, represents higher economy than 12.5 lb. per kilowatt-hour, which is said to have been developed by a large Curtis turbine at the station of the Chicago Edison Co. Presumably the latter figures have been incorrectly quoted from a test recently reported on a 9,000-kw. turbine at the station of the Chicago Edison Co., which showed a maximum economy of 12.9 lb. per kilowatt-hour at 10,000 kw. load.

Now, as far as I am able to ascertain, the basic facts are these: Taking both machines at their point of maximum economy, the Westinghouse-Parsons turbine developed a water rate of approximately 15.1 lb. per kilowatt-hour output at the switchboard for two consecutive hours with an average steam pressure of 175 lb. gauge, 97° superheat and 27.3 in. vacuum. Correcting to contract conditions, 175 lb. pressure, 100° superheat and 28 in. vacuum, this is equivalent to 14.73 lb. per kilowatt-hour. The Curtis turbine, on the other hand, developed 12.9 lb. per kilowatt-hour, with 176 lb. pressure, 147° superheat and 29.5 in. vacuum. Correcting to the above contract conditions by percentages advocated by the builders of these machines, it develops that the equivalent water rate at the same load, is 15.08 lb. per kilowatt-hour. These results might be reduced still further, to a basis of dry-saturated steam, and still be within the limits of your published statement regarding the economic record established by the New York Edison tests, I believe the above figures will be sufficient for the point in view.

The inference drawn from the above, is that economy tests are not comparable from either a technical or a commercial standpoint, unless respective operating conditions are known, so that it is manifestly improper to question the accuracy of your published report upon such a superficial basis. And, in making comparisons, such as these (which heretofore have seemed neither necessary nor opportune), I do so purely in the interest of a clear understanding of the situation, not for the purpose of drawing illusive conclusions even though the latter may be quite tenable on careful analysis. In examining the performance of prime movers, we must not simply accept the rate of consumption of heat energy in the form of steam, gas or oil, but make comparisons on a true, scientific basis, else the results will quickly lead to erroneous conclusions. The sooner these principles are clearly understood and appreciated at their true value, the sooner will the apparently great disparity between turbine tests, such as those above outlined, be dispelled.

And herein, by the way, lies the greatest fallacy in the ceaseless struggle for high economies. Every engineer is, of course, interested from a personal standpoint, in the attainment of the highest cyclical efficiency for all forms of prime movers; but high efficiency, *per se*, means little from a commercial standpoint unless the cost of attaining it is reckoned. This is particularly true of the extreme operating conditions assiduously cultivated in turbine operation. Unquestionably, the results are spectacular, but when we take into consideration the extra cost, maintenance, the complexity of the additional auxiliary equipment, and the losses incident

thereto, our enthusiasm wanes, and we intuitively seek a lower plane where efficiency and cost form a more reasonable balance.

J. R. BIBBINS.

CONCRETE PILES.

SIR: In a recent paper read by Mr. Charles R. Gow before the Boston Society of Civil Engineers, relating to experience in molding and sinking concrete piles, Mr. Gow referred to concrete piles constructed or built in place and those cast and driven. Piles constructed as mentioned were limited as to their length and their carrying capacity by reason of natural formation of soil penetrated, the composition of the material under and around the pile, which ultimately carried the load, and an approximate load of thirty tons was considered safe. Quoting Mr. Gow, "The extreme length of many of the piles introduced a serious question as to how best to handle them and avoid breakage. Piles up to 30 ft. in length could be picked up by the end without producing any undue strain; but over 30 ft. long, they almost invariably crack."

There has been considerable interest manifested of late in concrete pile construction. Further observations are hereby submitted relating to reinforced concrete piles produced by the rolling process, which is a decided departure from that introduced by Mr. Gow in his report. A specially designed machine for manufacturing and rolling round piles has been produced. Reinforced piles of various lengths and diameters have been made and used, giving considerable satisfaction.

Piles manufactured as stated can be driven by an ordinary pile-driving plant or a water jet. Experience has shown that they can be driven through all kinds of soil and endure the roughest kind of treatment without injury. Such piles were driven for the Erie Railroad at Susquehanna, Pa., under the foundation of the power house. They were constructed in various lengths up to 34 ft., and from 14 to 16 in. in diameter. The material penetrated was clay filling, furnace slag, and river silt to rock. On the Brighton Beach & Coney Island branch of the Brooklyn Rapid Transit Ry. four station foundations were constructed, using longer lengths, driven to compact gravel.

It has been observed that a concrete pile, in order to compete with a wooden pile, should be able to carry a much larger load than 30 tons by reason of its cost, and friction should not be relied upon to sustain the pile, as friction as a condition limits its application. When longer lengths are used and the piles driven to a firm foundation, 100 tons can be safely carried. Consequently fewer concrete piles can be used, replacing a larger number of wooden ones. The frictional resistance is no more than the pressure brought to bear by the displaced material through which the pile penetrates. Piles constructed in place where the displaced material is removed, have practically no frictional resistance, as shown by sinking tubes in deep well construction. They are easily driven after the material has been removed, with no great resistance. Piles built in place are very imperfectly reinforced, often not reinforced at all, which limits their carrying capacity.

Referring to the piles driven, manufactured as before stated, they were made by a machine set up at a convenient place. The reinforcing members consisted of a central tube, 2 in. in diameter, to which was fastened a steel wire fabric, 6 ft. wide and the same length as the pile, made of No. 16 steel wire, spaced every half in., securely fastened to the tube; eight square steel bars were fastened to the mesh and placed parallel to the vertical axis of the pile, equally distant apart. The diameter of these bars varies with the length of the pile. The ratio of the

diameters has been determined by previous experiment. A pile 62 ft. long requires the bar to be 1 in. in diameter. They are arranged in such a way that when wound in the convolution of the mesh they occupy positions near the circumference of the pile equally distant apart. The function of these bars is two-fold. They reinforce the pile against breakage by reason of its own weight and add to the carrying capacity as well. The fabric with bars in place is placed in the machine, over which a layer of concrete is deposited.

The concrete consists of a mixture of one part of cement, two of sand, and three of coarse gravel, evenly distributed over the wire fabric. The whole is then made into a roll by the machine and bound about every 6 in. with a No. 10 malleable steel wire and fastened, which forms a hooping the entire length of the pile. The pile is removed from the machine on a long car, transported to a convenient place, plastered on the outside and pointed, and in seventeen days it is ready for use. Being round, it can be handled with great ease, rolled down inclines, dragged by a hawser attached to one end, or suspended in the middle, dropped from a platform or flat car and rolled down an embankment, all of which has been done to test the capabilities of handling piles constructed in this way.

In construction, compression is used by heavy rollers that squeeze out all voids. The concrete becomes a dense, homogeneous mass. The finished roll, before the concrete sets, is so firm that it can be rolled around without injury. It takes twenty minutes to make a pile 35 ft. long.

This reinforcement of a pile with interlaced wire mesh, wound in convolution about a central steel tube, under compression rollers and bound

driven by a pile driver. No cracks or defects could be discovered. They were driven by an ordinary pile driving hammer, weighing 2,500 lb. A cylindrical cap was used, containing a diaphragm. Below the diaphragm on top of the pile was a coil of old rope; above the diaphragm was 6 in. of sawdust and a wooden follower block, that received the blows of the hammer. The piles were of various lengths, from 30 to 35 ft.,

REINFORCED CONCRETE BEAMS.

SIR: Perhaps in this era of reinforced concrete construction, you may deem it advisable to submit the enclosed diagrams to your readers. They were devised by the writer some time ago, while designing structures for the U. S. Reclamation Service in the West, and have saved him many hours of unnecessary work. By using a slide rule in obtaining the bending moments,

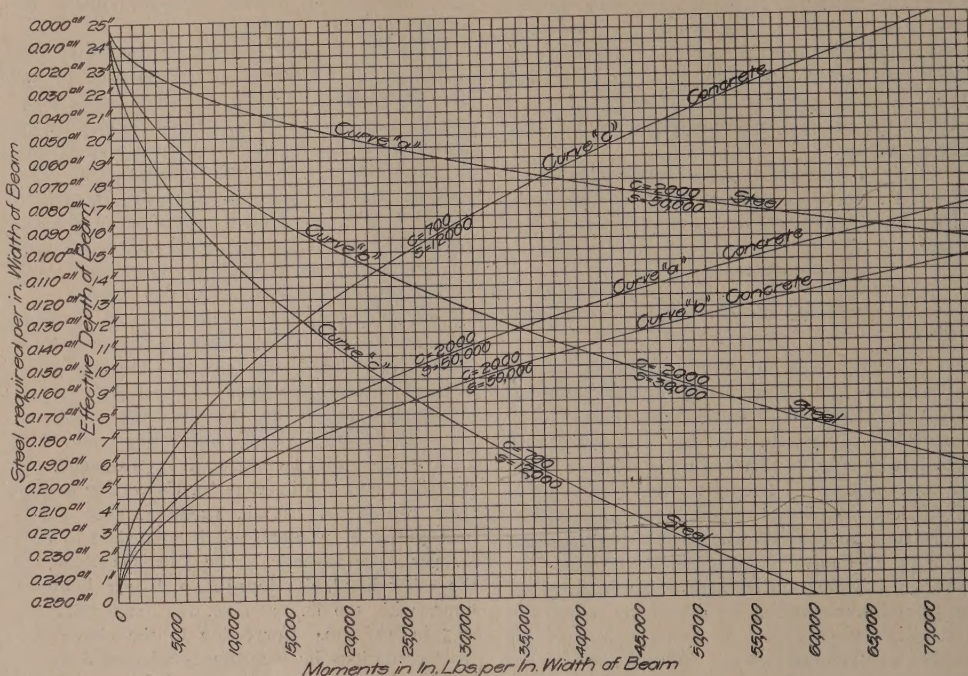


Diagram "A" for the Design of Reinforced Concrete Beams.

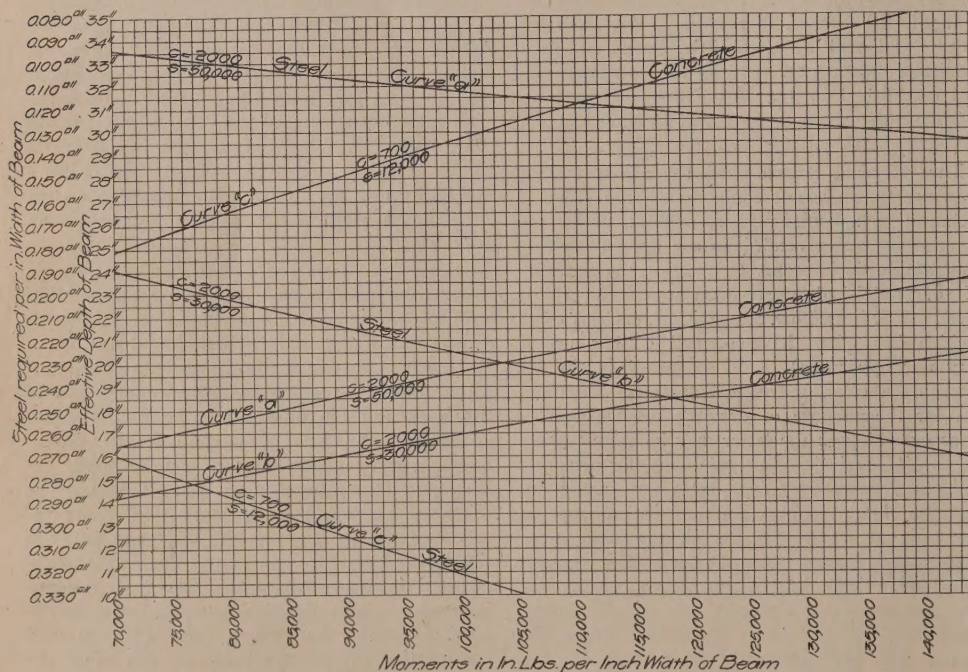


Diagram "B" for the Design of Reinforced Concrete Beams.

about the exterior at regular intervals, produces a hooped column action (brought out at a recent test made as to the load capacity of columns); and also a close connection of concrete and steel, whereby a simultaneous working of the two materials is obtained, when a load is applied.

The piles made for the foundation mentioned in Brooklyn, were rolled off skids, up an incline, to flat cars, transported to embankments 30 ft. high, dropped off the cars, rolled down the embankment. When used a hawser was attached to one end, and in one case they were dragged 200 ft. over two tracks, by a winch

driven through the embankment to hard, compact gravel.

The piles driven at Greenfield Ave. station required 450 blows to drive them to hard, compact gravel, where they refused to move any further. The hammer was dropped 15 ft. and weighed 2,300 lb. A mixture of concrete of 1, 2 and 3, using gravel, seems to be far superior for pile construction than any other mixture, and is recommended particularly where water is to be encountered.

ALEXANDER CRAWFORD CHENOWETH.
Brooklyn, Dec. 7.

and then the diagrams, the depth of a beam and the necessary reinforcement can be determined in a few minutes.

The bending moment in inch-pounds per inch width of beam is first obtained and multiplied by the factor of safety desired. Apply this to the bottom of the diagram, run up the vertical lines until the curve for concrete is intersected, and then run horizontally to the side of the diagram where the depth of the beam will be obtained. From $2\frac{1}{2}$ to 3 in. more must be allowed for the covering of the bars. The same process followed to an intersection with the steel curve and then to the side of the diagram will give the steel required per inch width of beam.

Curves *a* are for a compressive strength in the concrete of 2,000 lb. per square inch and an elastic limit in the steel of 50,000 lb. Curves *b* are for a compressive strength in the concrete of 2,000 lb. and an elastic limit in the steel of 30,000 lb. With curve *c*, the factor of safety is already applied, or, rather, safe unit stresses of 700 lb. for concrete and 12,000 lb. for steel are used. The bending moment as found is applied directly to the bottom of the diagram. These diagrams are based on Taylor and Thompson's straight-line formula, the theory of which can be found in their book on "Concrete, Plain and Reinforced."

Very truly,

HENRY A. YOUNG.

Camaguey, Nov. 18.

PRIZES FOR TRACK SUPERVISORS to the value of \$5,400 were distributed by the Pennsylvania R. R. in October for the tracks maintained in the safest and most perfect condition. The largest prize, \$1,200, was for the line best maintained during the year, and the next largest, \$1,000, for the division showing the greatest improvement. The remainder of the sum was divided into four \$800 prizes for divisions showing especially good maintenance and improvement.